Essays on the Determinants of Labor's Value Added Share

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Abstract

This dissertation consists of four essays on the functional distribution of income and contributes to the body of research on labor markets and macroeconomics. The first essay reviews the literature on the income share of labor. The second essay analyzes empirically the impact of investments into information and communication technology (ICT) on the relative compensation of high-, medium-, and low-skilled workers. The results imply that, although ICT investments influence the relative demand of workers by skill, this impact is not persistent over time and across countries. Nevertheless, individual industries are identified in which ICT investments increase the relative compensation of high-skilled workers and industries in which ICT investments polarize compensation at the bottom of the skill distribution. The third essay investigates the empirical influences on the labor share in Western Europe. The results show a large and persistent negative impact of economic integration on the labor share in the medium-run for an industry-level measurement. Stronger labor market institutions increase the labor share. Furthermore, the results suggest a common negative impact of ICT and economic globalization on labor share, while ICT itself seems complementary to labor in production. The fourth essay assesses empirically through which channel ICT decreases the labor share. The model of Bental and Demougin (2010), which argues that ICT reduces the labor share by improving monitoring technology and therefore lowering the workers rent at every level of output, is calibrated and simulated using data from nine OECD countries. The results show that the model can generate the observable trends in the labor shares as well as real wages in efficiency units and labor in efficiency units over capital. Furthermore, an analysis of micro data from the German Socio-Economic Panel indicates an overall average increase of perceived monitoring of workers between 1985 and 2001

Keywords:
Labor Share, Functional Income Distribution, ICT, Skill, Income Inequality, International Trade, Labor Demand, Monitoring

Zusammenfassung

Diese Dissertation besteht aus vier Aufsätzen, die sich mit der funktionalen Einkommensverteilung beschäftigen und leistet einen Beitrag in den Bereichen Arbeitsmärkte und Makroökonomie. Der erste Aufsatz ist ein Literaturüberblick über den Einkommensanteil von Arbeit am Gesamteinkommen. Der zweite Aufsatz analysiert den Einfluss von Informations- und Kommunikationstechnologien (IKT) auf den relativen Lohnanteil von hoch-, mittel- und niedrig qualifizierten Arbeitnehmern. Die Ergebnisse der Untersuchung legen nahe, dass IKT die relativen Lohnanteile beeinflusst, dieser Einfluss jedoch nicht im gleichen Maße über Zeit und Länder auffindbar ist. Einzelne Industrien werden aufgezeigt, in denen Investitionen in IKT den relativen Lohnanteil hochqualifizierter Arbeitnehmer steigern. In anderen Industrien führen Investitionen in IKT zu einer Polarisierung am unteren Ende der Verteilung. Der dritte Aufsatz untersucht die Einflüsse auf die Lohnquote in Westeuropa. Die Studie zeigt einen großen und persistenten negativen Einfluss von internationaler wirtschaftlicher Integration auf die Lohnquote über die mittlere Frist. Starke Arbeitsmarktinstitutionen steigern die Lohnquote. Der vierte Aufsatz untersucht durch welchen Kanal IKT die Lohnquote beeinflusst. Das Modell von Bental und Demougin (2010), welches die Hypothese aufstellt, dass die Lohnquote fällt da IKT die Beobachtbarkeit von Anstrengung erhöht und so die Informationsrente der Arbeitnehmer bei gleicher Anstrengung senkt, wird zu Daten von neun Westeuropäischen Ländern kalibriert. Dies zeigt, dass das Modell die Trends der Lohnquote als auch die der Reallöhne in Effizienzeinheiten und der Arbeit in Effizienzeinheiten durch den Kapitalstock, replizieren kann. Desweiteren zeigt die Analyse von Individualdaten aus dem Deutschen Sozio-Ökonomischen Panel, dass die gefühlte Beobachtung der Arbeitsleistung im Durchschnitt zwischen 1985 und 2001 gestiegen ist.

Schlagwörter:
Lohnquote, Funktionale Einkommensverteilung, IKT, Qualifikation, Einkommensungleichheit, Außenhandel, Arbeitsnachfrage, Beobachtung der Arbeitsleistung

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1 Introduction

This dissertation studies the distribution of income across factors of production. The functional distribution of income describes how the income from production is distributed across the factors of production. In macroeconomic theory the creation of gross value added is thought to employ two factors: capital and labor. The distribution of income across both factors is described by the shares of income each factor receives. The remuneration of work and capital investments in production is shaped by technological and institutional factors. Technology, institutions, and the economic environment have changed dramatically in the last decades in OECD countries. While firms are faced with higher competition in integrated world markets, the amount of potential customers also increases. However, not only the trade of products is globalized and changed through information and communication technology (ICT), but also its production. Through globalization and new technology workers compete not only with foreign workers for their jobs, but their jobs themselves have also changed through technological innovations. Michael Spence (2011) describes how globalization is now at the point where emerging market influence developed economies, especially their labor markets. Globalization in combination with ICT innovations influence labor market outcomes. International trade increased significantly in all OECD countries over the last decades and ICT-investments as a share of value added increased even exponentially over the same period. Furthermore, while in the 1970s labor unions were strong and led to high salaries and employment and therefore a high labor share in continental Europe, the last 35 years are characterized by changes in union density and coverage as well as employment protection. Globalization, technological change, and changes in labor market institutions have influenced labor market outcomes and consequently the distribution of income across production factors. The aim of this dissertation is to investigate how these changes influence the distribution of income between capital and labor and the relative income from production of labor with differences in skills since the 1970s and 80s.

After an increase in the 1970s and 80s, in most OECD countries the labor share has decreased over the last 35 years. While the labor share moved around a constant trend

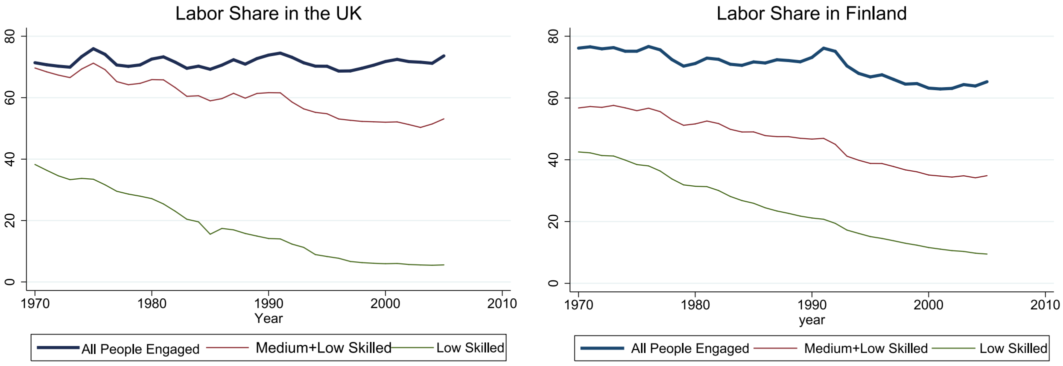

Figure 1.1: Labor Share and its Composition by Skill in the UK and in Finland; source: EU KLEMS, Author's Calculations.

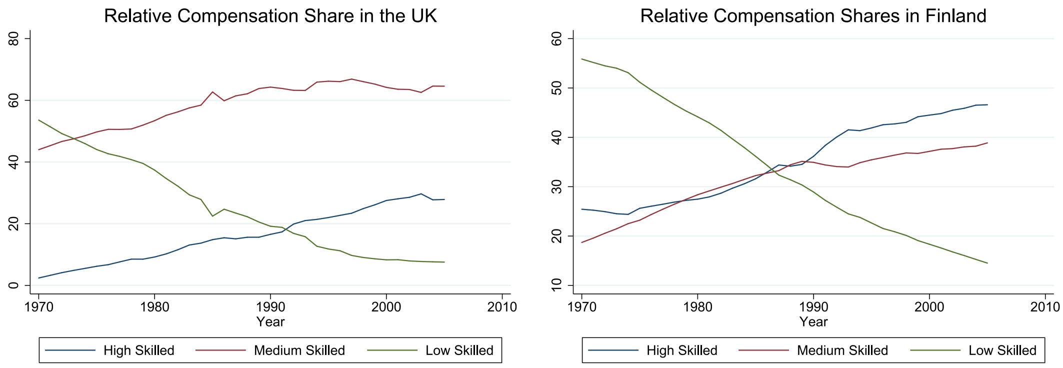

Figure 1.2: Relative Compensation Shares in the UK and in Finland; source: EU KLEMS, Author's Calculations.

in the UK, it decreased in continental European countries since the 1980s. In the US a decrease in the labor share is observable in the data since 1990. Figure 1.1 shows the labor share exemplary for the UK and for Finland between 1970 and 2005. The thick upper line is the overall labor share. As mentioned above, it fluctuates around a constant in the UK, while it decreases from 73 percent of GDP to 64 percent in 2005. The red lines show the share of GDP which is received by the workers with medium- and low-skills, and the green one the share which low-skilled workers receive. The difference between the dark blue line and the red line reflects the share of high-skilled workers. Even though the overall trends are different between the UK and Finland, in both countries the share of GDP that medium and low-skilled workers receive fall since 1970.

The drop of the low-skilled labor share is reflected in the distribution of total labor income across skill groups. Figure 1.2 shows the division of total labor income across skill groups in the UK and in Finland between 1970 and 2005. The relative compensation share of low-skilled workers has decreased in all Western European countries, as well as in other OECD countries such as the US, Australia, Japan, and Korea. High-skilled compensation shares have increased at the same time.

The figures 1.1 and 1.2 show how the labor share can be divided into incomes by skill. Figure 1.1 essentially describes the following relationship

$$s_L = \frac{wL}{Y} = \frac{w^l L^l}{Y} + \frac{w^m L^m}{Y} + \frac{w^h L^h}{Y}, \tag{1.1}$$

where s_L is the labor share, which describes wages, w, times employment, L, over value added Y. The sum on the right hand side of the equation describe the share of value added that workers of specific skill groups received. Here labor is divided into three skill groups: low, l, medium, m, and high, h. It could also be assumed that the production of different products vary in their technology and use different input ratios. Value added on an aggregate level could be thus described by

$$Y = \sum_{j=1}^{M} Y_j = \sum_{j=1}^{M} F^j \left(L_1, ..., L_N\right). \tag{1.2}$$

where M is the amount of outputs Y^j, which are produced by the respective production function F^j using the labor inputs L_i. In equation (1.1) there are three different labor inputs such that $N = 3$ and i is either l, m, or h. The labor share can therefore be further described by

$$s_L = \sum_{j=1}^{M} \sum_{i=1}^{N} \frac{w_i L_{ij}}{Y_j} \frac{Y_j}{Y}. \tag{1.3}$$

$\frac{w_i L_{ij}}{Y_j}$ is the share of the ith labor input in the production of output j. $\frac{Y_j}{Y}$ is the share of output j in aggregate value added. Shifts in the labor share can therefore be divided into shifts in the labor share by skill in the production of goods and shifts in the share of value added of goods with differences in the labor share.

In this thesis I address the question of why we see these movements of absolute and relative income shares by empirical analyses of country and industry data for OECD countries. I address the following questions:

1. Is there a persistent influence of ICT investments on the relative compensation shares by skill?

2. What factors influence the movements of the labor share in the short and medium-run?

3. Is ICT reducing the labor share by improving the firms' monitoring technology?

In the remainder of the introduction I will give a short overview of the chapters of this dissertation and will describe my main contributions.

The second chapter reviews the literature on the labor share. Since Ricardo (1821), the distribution of income across the factors of production has frequently been analyzed and motivated research in related areas. As the share of labor in total income is defined by the sum of labor income over value added, every economic theory that cares about setting wages and/or employment is related to the labor share. Sometimes ideas about the labor share lead to the design of a new theory, for example in growth or production theory, and in other circumstances the labor share itself is the main subject of the analysis. Since the 1920s researchers used an observed stability of the labor share in the US to create ideas on the overall production function (Cobb and Douglas, 1928; Arrow et al., 1961). This stability was largely discussed among researchers and led to the stylized fact the factor shares are roughly constant (Kaldor, 1961). This finding is included in many models for example on economic growth (Solow, 1956). In these models the labor share is determined in complete markets where all factors are remunerated by their marginal product. Theories on the cyclical movement of the economy often depart from this assumption and introduce frictions in the labor market (Pissarides, 2000). Here, the distribution of income is still influenced by technology, but also by institutions. This influences the labor share by introducing cycles. As labor share in OECD countries have been falling since the 1980s, the functional income distribution became again a subject on its own and a main concern that needed to be explained (Blanchard, 1997). The literature review in chapter 2 explains the ideas on the labor share and its influence on fields like growth theory or business cycles in more detail. I also use the chapter to define the labor share in more detail and explain the empirical challenges in measuring labor's income share.

The third chapter analyzes the impact of ICT investments on the relative compensation of high-, medium-, and low-skilled workers.[1] This study is part of a literature that

[1] This chapter is based on Braun et al. (2009, Part III) which is a study on "The Impact of ICT on Employment" written for the European Commission. Part III deals with the impact of ICT on labor market outcomes of workers by skill groups and includes an extensive literature review on the subject.

tries to understand the reasons for increasing income and employment inequality within OECD countries. In the early 1990s several studies found the income distribution in the US to be widening since the 1980s, as the so called college-premium increased (Katz and Murphy, 1992; Levy and Murnane, 1992; Bound and Johnson, 1992). Davis (1992) and the OECD (1993) find similar developments of increasing demand for high-skilled workers in continental Europe. The reason mostly found for this increase in inequality by skill was technological progress (Katz and Murphy, 1992; Berman et al., 1998; Krueger, 1993). This created the notion of skill-biased technological change which describes technological progress which is not neutral across skill groups, but favors high-skilled work. The ideas was that innovations in ICT such as personal computers are substitutes to low-skilled work while high-skilled work are complements. As prices for computers fall, wages for lower skilled workers fall accordingly. Following the skill-biased technological change hypothesis there is a linear relationship between skills and ICT where the least skilled workers are the closest substitutes to ICT and the high-skilled are most complementary. More recent literature find a polarization in the income distributions in OECD countries, such as the US, Germany, or the UK (Autor et al., 2003; Spitz-Oener, 2006; Goos and Manning, 2007; Dustmann et al., 2009). The polarization describes a continuing increase of wages and employment at the upper end of the income and skill distribution and a reduction of employment and income in the middle. This is frequently explained by complementarity or substitutability of ICT capital and labor. The distinctions between the labor inputs are not made by the skill level of a worker, but by the task the worker performs. The hypothesis of this "task"-literature is that workers in the middle of the income and skill distribution perform more tasks which are routine and can be performed by a computer as well. High- and low-skilled workers perform rather non-routine tasks which are complements to routine tasks in production.

In chapter three, I contribute to the analysis of the increasing divergence of relative income by skill by estimating the impact of ICT-investments on the relative compensation share of high-, medium-, and low-skilled workers. In this analysis I follow the studies of Machin and Van Reenen (1998) and O'Mahony et al. (2008), who also estimate a similar econometric setup in an industry-country-panel. I estimate the impact of ICT investment on the relative shares for 14 countries and find no persistent impact on the relative compensation shares across time and across countries. Only in a few countries, Australia, Denmark, and Korea, ICT investments have the expected positive influence on high-skilled workers compensation shares. I find a polarizing impact of ICT investments on the lower end of the skill distribution in Austria, Germany, Italy, and the US. Estimating the econometric setup industry-wise instead of country-wise lets me determine in which industries ICT investments are complements to high-skilled work and in which industries ICT investments cause a polarization on the bottom. I find five industries in which high-skilled workers gain in their relative compensation due to ICT-investments, and another five industries in which medium-skilled workers are negatively influenced and low-skilled positively influenced by ICT investments. Using the long panel structure of the data, I re-estimate everything under the assumption of a structural break in the mid 1990s. I find that the positive impact of ICT investments on high-skilled workers is mostly driven by the period before 1994 and that the influences on medium- and low-skilled workers are mostly observable in the later period after 1994. In summary, I show with a large and detailed dataset that ICT investments have an influence on the relative compensation shares, but this influence is not persistent over time and across countries as expected from previous studies.

The fourth chapter returns to the labor share and the more aggregate division of income across production factors. In a unified framework, I analyze theoretically and empirically how changes in institutions, bargaining power, economic integration, and technology influence the labor share in Western Europe. Although there is evidence that the labor share is a function of the available technology and especially the capital stock (Bentolia and Saint-Paul, 2003), recent literature on the labor share has also investigated non-technological influences on the share. Using a Nash-Bargaining framework[2] it is assumed that workers and firms bargain over the rents from production. This framework is similarly implemented by Bentolia and Saint-Paul (2003), Arpaia et al. (2009), the European Commission (2007), Checchi and Garcia-Penalosa (2010), and Jayadev (2007). I combine the theoretical assumptions that workers and firms have bargaining power and outside options. The outside option of the worker is is determined among other things by unemployment benefits. The firm is able to offshore production abroad. Furthermore, I allow competition to be not perfect such that firms are not necessarily price takers. Using this theoretical framework as a basis, I estimate the influence of the capital-stock, ICT-capital investments, union coverage, unemployment benefits, unemployment rate, restrictions on globalization, and trade flows on the labor share in large industry-country panel. Using an error-correction framework allows me to differentiate between long and short-run influences. In the long-run, only the capital-output ratio and economic globalization influence the labor share.

As shown in figure 1.1, underlying the labor share are individual labor shares by skill. As described above, it is possible that the individual regressors have a different impact on the labor market outcomes of workers depending on their skills. Capital and ICT

[2]cf. McDonald and Solow (1981).

may be complementary or a substitute to work of a specific skill group. Similar assumptions can be attributed to work abroad. Some skills may be easier to substitute by foreign workers. Labor market institutions may also affect workers of the various skill groups differently. Therefore, I estimate the error-correction model for the shares of aggregate income of the separate skill groups. Capital has a common positive long-run impact on all skill groups. Labor market institutions have compressionary influences on the income distribution by skill. High- and medium-skilled workers' shares are negatively influenced by increasing trade flows while the low-skilled workers' share decreases through decreasing trade restrictions.

Economic integration and ICT innovations are closely connected. Both increased significantly over the last decades. Additionally, ICT enables offshoring as it facilitates communication with subsidiaries, but also the transfer of products, especially in services. Therefore, I take account of the common and the individual impact of ICT and economic integration. As the measure for decreasing trade restrictions is an indicator for potential trade, this estimation shows that increasing ICT investments enable offshoring which reduces the labor share. The individual impact of ICT on the labor share is then positive as ICT complements labor in production. This finding is especially pronounced in the service sector and for medium-skilled workers.[3]

In chapter five, I also analyze the impact of ICT on the labor share and ask through which channel does ICT influence the labor share. This study follows the model by Bental and Demougin (2010) who model the decreasing labor share as results of decreasing bargaining power of workers as ICT innovations improve the monitoring precision of the firm. As firms observe the effort of workers more precisely, the firm needs weaker incentives in order to generate the desired level effort. As information rents of the workers decrease the labor share falls. Next to a falling labor share, Bental and Demougin (2010) also explain a decline of real wages in efficiency units and a declining rate of labor in efficiency units to capital. These are due to the fact that firms invest in capital before bargaining with workers takes place. This reduces the investment incentives for firms. As the bargaining power of the workers fall, due to the improved monitoring technology, the firms incentives to invest into capital increase as they can secure a higher share of the overall income. In my analysis, I evaluate the hypotheses of the model by Bental and Demougin (2010) on the macro and micro level.

In a first step, I calibrate and simulate the model for nine OECD countries. I show that with a couple of adjustments, the model by Bental and Demougin (2010) can replicate the trends of the real world data. I adjust the model such that the user costs of

[3]This is in line with findings of Braun et al. (2009).

capital are not necessarily constant. Furthermore, I allow for a non-optimal determination of bargaining power, implying a biased political decision rule for either capital or labor. In a second step, I analyze micro data from the German Socio-Economic Panel (SOEP) on the perceived monitoring intensity of workers. I show that while individuals feel less monitored as they progress in their careers, the average perceived monitoring increased between 1985 and 2001, even after correcting for covariates such as education or the occupational position. These results indicate that monitoring technology improved and reduced workers' income. While the literature concerning skill-biased technological change or the "task"-literature assumes the impact of ICT on wages and employment is due to the technical substitutability of work and ICT, the findings of Bental and Demougin (2010) and my study imply that ICT weakens the moral-hazard problem between workers and employers and that wages may have decreased as a result of a reduction in information rents.

2 The Labor Share: A Review of Theory and Evidence

2.1 What is the Labor Share

The labor share is defined as the share of value added which is payed out to workers. It is therefore often also called the wage share. Generally it is assumed that value added is produced with capital and labor as input factors so that $Y = F(K, L)$ where Y is value added or output[1], K the capital input, and L labor. The labor share is thus defined as:

$$s_L = \frac{WL}{PY}, \tag{2.1}$$

W is the wage and P the price of output. The labor share is the nominal wage bill over nominal output or nominal GDP. This fraction is also known as real unit labor costs. Nominal unit labor costs, which play a significant role in monetary economics, are defined as the nominal wage bill over real output: $ULC = \frac{WL}{Y}$.[2]

The labor share is a key indicator for the distribution of income in a country. It shows how much of national income is distributed to labor and how much to capital. With two factors, it follows that the capital share is $s_K = 1 - s_L$. The capital share includes all non-labor income including interest income and economic profit which can be added together and be defined as accounting profit (Mankiw, 2007).

Empirically the labor share is usually defined as total labor compensation or labor costs over nominal GDP or nominal value added. As Krueger (1999) points out, this is not necessarily straightforward. He poses the question how each part of the labor share should be defined. Especially total labor compensation is not clearly defined. Compensation may include other benefits, such as stock options, it may or may not include income of self-employed or benefits of retirees such as health care.

Gomme and Rupert (2004) address these issues and define in detail how the US Bureau of Labor Statistics measures the labor share. Labor compensation, WL, is defined here as

[1] In what follows value added and output are taken to mean the same thing.
[2] Cf. Burda and Wyplosz (2009) pp. 291.

compensation of employees minus government wages and salaries, compensation of employees of non-profit institutions, private consumption, farm compensation of employees, housing compensation of employees and adjusted for the imputed labor compensation of self-employed. The OECD provides several data sources for labor compensation. In the National Accounts, labor compensation is defined as “Wages and salaries payable in cash or in kind” plus “the value of social contributions payable by employers” (OECD, 2009). This is close to the definition by Burda and Wyplosz (2009). The OECD provided measurement of the labor share adjusts the measure of labor compensation by self-employed which is the total labor costs.

The adjustment of self-employed is a widely discussed topic in the literature. Especially in sectors with a high share of self-employed their income may change the labor share significantly. Krueger (1999) simply attributes two-thirds of proprietors income to wage bill in order to calculate the labor share. The OECD, the US Bureau of Labor Statistics, and the EU KLEMS adjust labor compensation by self-employed by assuming the same average wage of self-employed and employees in the sector. This will lead to measurement errors as in different countries and sectors the wages of employees and self-employed may differ significantly (McKenzie and Brackfield, 2008; Arpaia et al., 2009; Gomme and Rupert, 2004; Timmer et al., 2007b).

The definition of value added, PY, is also not immune to differences in measurement. The OECD (2009) defines value added as “as the difference between gross output (at basic prices) and intermediate consumption (at purchasers prices)” which is in detail compensation of employees, gross operating surplus, mixed income, and other taxes on production less subsidies on production. McKenzie and Brackfield (2008) discuss the problem of subtracting all subsidies and adjusting for taxes from the measurement. Gomme and Rupert (2004) discuss further complications in the measurement of value added, such as the government’s capital income or a lack of labor income in the housing sector. Corrado et al. (2009) indicate the missing measurements for intangible assets, which should be accounted for in value added and would be attributed to capital income. Also the inclusion for the informal sector is relevant for the measurement of value added and the labor share (Jayadev, 2007; Lübker, 2007). Especially in developing countries, where the informal sector is large, this may play a role.

These definition issues not only affect analyses which cover multiple countries, but also analyses over a longer time frame. Figure 2.1 shows the labor share in Germany since 1925 as computed by the German statistical office (source: Destatis, National Accounts). Here the share is defined as labor income of employees over GDP which is corrected for taxes and subsidies. The German case shows already problems for a long

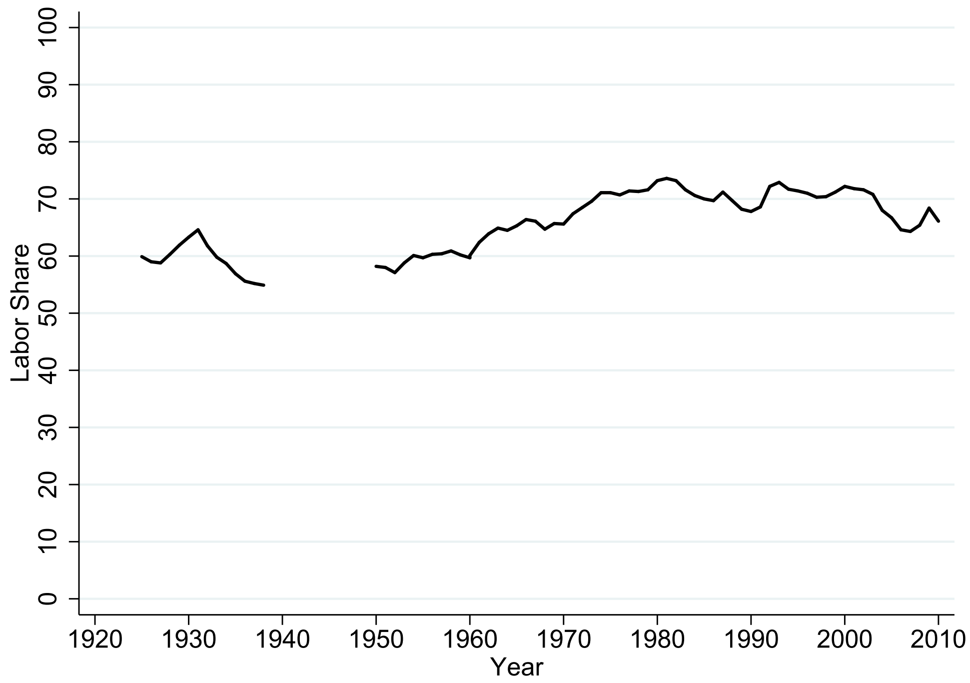

Figure 2.1: Labor Share in Germany, Source: Destatis

series. In this case the data around the second world war is missing. The statistical office has, nevertheless, tried to give a harmonized series for data that comes essentially from three different Germanys: Germany before the second world war, West Germany and Germany after reunification. Figure 2.2 shows the labor share for the US since 1947 in quarterly data from the US Bureau of Labor Statistics as it is described by Gomme and Rupert (2004). This labor share covers the non-farm business sector and is adjusted for self-employed. With the different definitions regarding the labor share, a comparison of the German and the US labor share from both graphs should be only be done with caution.

Due to these difficulties, a common definition of the labor share and its components is necessary for cross-country analyses. For short and medium-run analyses of developed countries the OECD and EU KLEMS offer harmonized datasets also on an industry level. Figure 2.3 shows harmonized series for six exemplary countries from the AMECO database of the European Commission. This harmonized dataset starts in 1960 compared to the OECD and EUKLEMS which start 10 years later. The labor shares in figure 2.3 are also adjusted for self-employed. The German and US labor shares differ between the series above and the ones from the AMECO database. Nevertheless the trends are

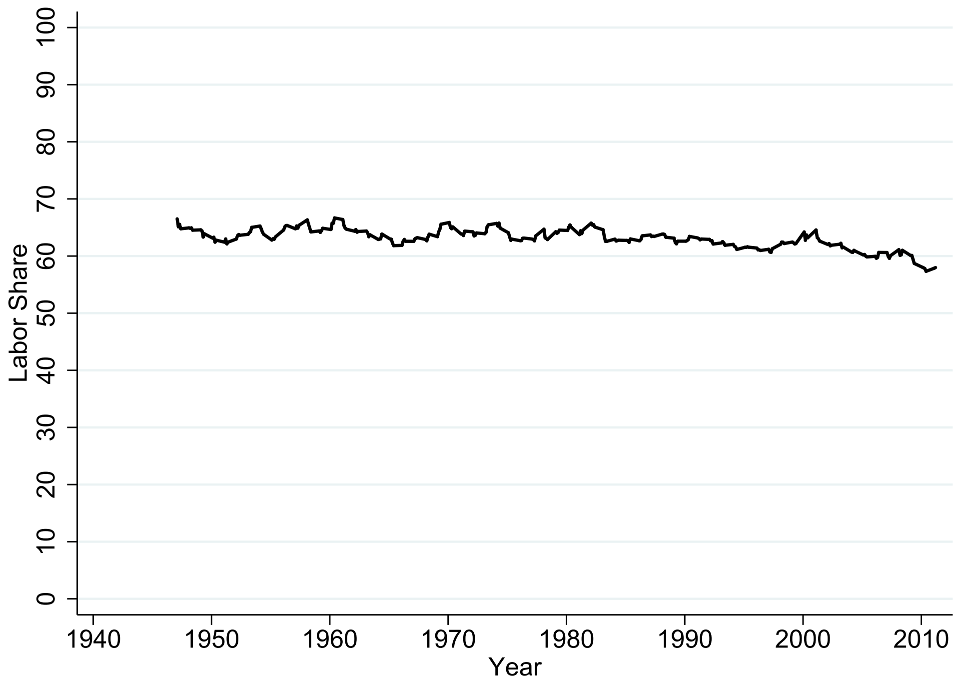

Figure 2.2: Labor Share in the US, Source: US Bureau of Labor Statistics

similar. These figures show that in empirical analyses concerning the labor share, the definitions of the share and the data source matter significantly.

2.2 The Labor Share Across Time and Ideas

The value of the labor share is determined by the level of employment, compensation payed, and the level of value added. These levels are determined at the labor and product markets and are thus subject to the behavior of labor demand, labor supply, and the level of output. In the short-run changes in the labor share depend on the volatility and timing of shifts in compensation and employment compared to total value of output. In the longer-run the level and changes in the labor share depend on the precise production function and the resulting labor demand as well as on the structure of the labor force and thus labor supply. Cobb and Douglas (1928) present their famous production function which has direct implications for the division of national income between workers and capital. Douglas (1976) writes about the interconnection of the theory of production and the issues of distribution:

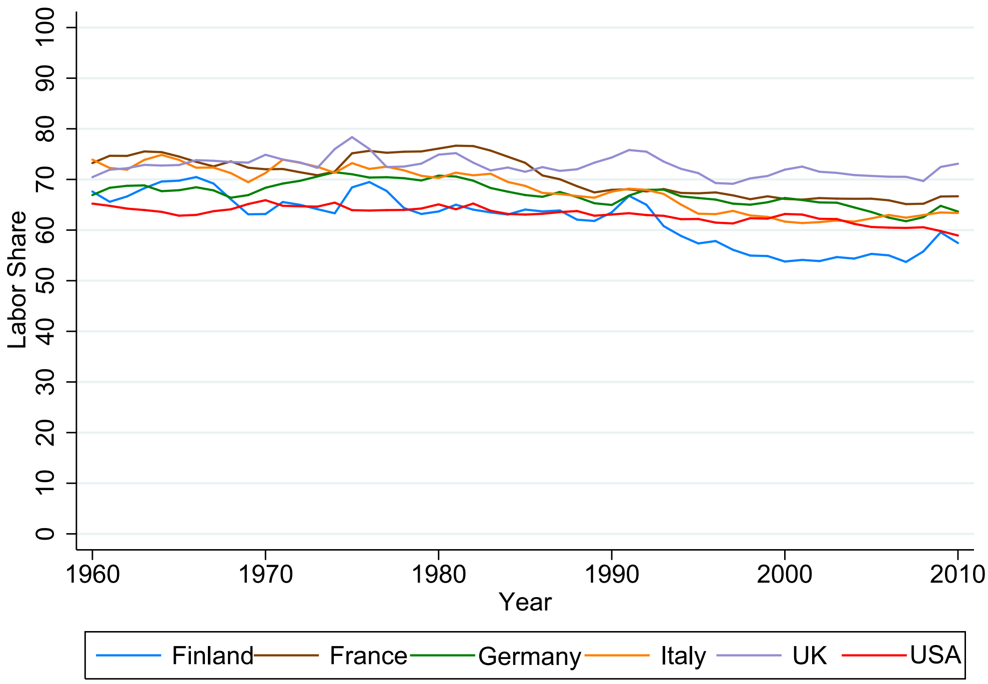

Figure 2.3: Labor Share in the Selected Developed Countries, Source: AMECO

> "We should not let these minor differences obscure the fact that a substantial degree of equality between k (output elasticity of labor) and $\frac{W}{P}$ (income share of labor) has been attained. That is the central fact, and it both gives further corroboration to the production function and tends to show that the distribution of the product closely conforms to what, in a largely competitive society, we would expect the marginal productivity of labor to produce. Both productivity and distribution therefore, mutually reinforce each other." and "The results of this study lend further corroboration to the accuracy of the production function as a description of manufacturing production and as a determinant of the distribution of the product - which is a separate but allied subject." (Cobb and Douglas, 1928, pp. 912-913).

Under the assumption that the remuneration of work equals the marginal product of labor, the theory of production usually has implications for the nature of the labor share and vice versa. I will address the theories of production and their implications for the labor share. Nevertheless, there are mechanisms which prevent a direct definition of the share from the production function due to the inequality of wages and the marginal product. The academic discussions of the labor share usually departs from observations in the data about the labor share. These empirical facts are then translated in new models of production functions or mechanisms of setting wages and employment. One discussion started at the early 20th century and grew intense in the 1950s and 60s. After ideas from this time became "stylized facts", the evolution of the share became a topic again in the mid 1990s when data began to denote from these facts. In the rest of this review I will address the empirical departures of the discussions and their theoretical conclusions.

2.3 From Classical to Neo-Classical Ideas on the Labor Share

Most researchers who try to explain the importance of the distribution of income across factors quote Ricardo (1821) who described this as the main problem of Political Economy. In a review on the implications of different economic theories on the distributive shares, Kaldor (1955) compares the ideas of Ricardo, Marx, Keynes, and the Neoclassics (or "Marginalists").[3] Specifically, Kaldor (1955) assesses the theories under the empirical finding of strikingly constant labor shares of national income, which is known also as Bowley's Law.[4] He analyzes the different theories across this notion of constant share:

> "In fact no hypothesis as regards the forces determining distributive shares could be intellectually satisfying unless it succeeds in accounting for the relative stability of these shares in the advanced capitalist economies over the last 100 years or so, despite the phenomenal changes in the techniques of production, in the accumulation of capital relative to labour and in real income per head." (Kaldor, 1955, pp. 83-84).

Discussing of the work by Ricardo and Marx, Kaldor (1955) describes their main ideas on the mechanisms of production, wage setting, and employment. Ricardo and Marx both believed that wages are independent of their marginal product and employment is inelastically supplied. While Ricardo stated that wages are set on a general supply price and the level of employment by the available capital, Marx believed wages to be merely at a subsistence level of the workers and that at all times the supply of workers outnumbered the demand at the given wage level.[5] According to Ricardo the labor share was thus variable and only depending on capital and the economic environment.[6] From Marx's theory it follows that the labor share is falling over time. As wages remain at

[3] Kraemer (2010) gives an extensive review of the classic literature concerning the notion of constant labor shares.

[4] Bowley's Law is named after Sir Arthur Lyon Bowley, a British statistician (1869-1957). See Kraemer (2010) and Bronfenbrenner (1971) for a discussion of the notion of "Bowley's Law".

[5] Cf. Kaldor (1955) pp. 84,85,87.

[6] Cf. Kaldor (1955) p.83 and Kraemer (2010) pp.7-8.

the subsistence level, output increases through increasing usage of capital per worker. Only if the workers would gain bargaining power, their wages could improve. If these would improve at the same rate as output per worker increases, this would lead at most to a constant share.[7] Kraemer (2010) argues that the labor share was not of central interest to the classical economists and therefore they were not trying to match data on the distribution of income. The neoclassical economists, on the other hand, created their models following empirical findings where the labor share plays a central role.

Compared to the classical theories, neoclassical theory assumes that all factors are remunerated at their marginal product. Important implications from the neoclassical theory on behavior of the labor share were derived by Marshall (1920) in his four laws of derived demand. These rules describe how changes in prices and volumes of inputs and total output are interconnected with the demand and supply elasticities. Hicks (1932) and Allen (1938) present mathematical formulations of Marshall's laws. A simple presentation of this can be found in the comprehensive discussion of the theory of labor demand by Hamermesh (1993, pp.23-29). He translates this to a simple production function with two inputs: capital and labor, which are both homogeneous. The production function is linear homogeneous which implies constant returns to scale,[8]

$$Y = F\left(K, L\right), \tag{2.2}$$

where Y represents output, K capital, and L labor. Further assumptions are $F_K > 0$, $F_L > 0$, $F_{KK} < 0$, $F_{LL} < 0$, and $F_{K,L} > 0$. Assuming perfect competition with given factor prices r and w and normalizing the output price to one, the firm maximizes profits by

$$max_{K,L} F\left(K, L\right) - rK - wL. \tag{2.3}$$

The first order conditions impose the marginal product of the input factor to be equal to its respective market price,

$$F_K = r, \tag{2.4}$$

$$F_L = w \tag{2.5}$$

[7] Cf. Kaldor (1955) p.88.

[8] Cahuc and Zylberberg (2004) analyze labor demand from the cost side of production analogously using the duality of profit maximization and cost minimization. They also include a mark-up from the product market in their analysis.

The elasticity of substitution is defined as:

$$\sigma = \frac{d\left(K/L\right)/\left(K/L\right)}{d\left(F_L/F_K\right)/\left(F_L/F_K\right)} \tag{2.6}$$

In the case of the linear homogeneous production function this is equivalent to:

$$\sigma = \frac{F_L F_K}{F_{LK} Y} \tag{2.7}$$

The elasticity of substitution states the ease with which the two input factors can be substituted for each other while keeping output constant, or in other words how easily capital and labor can be substituted for one another if the relative input price (which is the marginal rate of substitution in this case) changes.

From these derivations Allen (1938) shows, under the given conditions from above, how the *compensated* or *constant-output labor demand elasticities* and the *uncompensated* or *total labor demand elasticities* can be derived. The compensated labor demand elasticity in the terms of Hamermesh (1993, p.24) is

$$\eta_{LL} = -\left(1 - s_L\right)\sigma < 0, \tag{2.8}$$

$$\eta_{LK} = \left(1 - s_L\right)\sigma > 0. \tag{2.9}$$

η_{LL} states how much the amount of labor that is demanded by the firm is reduced if wages increase by one percent while output remains constant. The compensated cross-price labor demand elasticity, η_{LK}, analogously describes the change in the amount of labor that is demanded due to a one percent change in the price for capital. The uncompensated demand elasticities, η^*_{LL} and η^*_{LK}, describe how much labor demand changes due to a change in input prices if the input is not adjusted in a way that output remains constant.

$$\eta^*_{LL} = -\left(1 - s_L\right)\sigma - s_L\eta \tag{2.10}$$

$$\eta^*_{LK} = \left(1 - s_L\right)\left(\sigma - \eta\right) \tag{2.11}$$

The change in the demand for labor due to a change in wages thus depends on a substitution and a scale effect. The substitution effect results from the compensated labor demand elasticity. The scale effect comes into play as the price for the output of the firm increases if wages increase relative to share of labor in total production. If the price of the good increases the product demand decreases according to the price elasticity of demand for the product, η. These derivations contain the laws of demand by Marshall (1920) as they are also described by Hicks (1932, p.242): The uncompensated labor demand elasticity is higher (i.e. the change in the amount of labor demanded by the firm due to a change in wages is higher) (1) the higher the price elasticity of demand for the product, η; (2) the higher the elasticity of substitution, σ; (3) the higher the supply elasticity of the other input factor; (4) the higher the labor share, s_L. The first law stems from the scale effect. If the amount of output demanded reacts strongly to price increase which is due to an increase of wages, the amount of labor used in production will be reduced more as less output is produced. Law number two explains that less labor per unit capital will be used in production if the two input factors are closer substitutes if the relative price of labor increases. As the share of labor reflects the total cost of labor in production, the fourth rule reflects the scale effect. If the share of the overall costs is relatively high, a one percent increase in wages will lead to a higher cost increase and thus a higher output price increase. These rules play a great role when explanations for the behavior of the labor share over time are assessed and changes in wages and employment are taken into account.

Cobb and Douglas (1928) developed a theory of production based on observed time series data from American manufacturing which fits well into the Marshall-Hicks-Allen framework. Analyzing the relations of capital and labor input as well as a production index, they found the data to be matching a homogeneous production function of order one.[9] Cobb and Douglas (1928) employed the function:

$$Y = bL^{\beta}K^{1-\beta}, \tag{2.12}$$

which has previously been introduced by Knut Wicksell[10]. Y is output, L is labor, and K is capital. They estimated this function, which has been known from then on as the Cobb-Douglas production function, with OLS and find for the data at hand that $b = 1.01$ and $\beta = 3/4$. This function has several special features. The marginal product of labor is $\beta\frac{Y}{L}$ which is again equal to the average product of labor. The elasticity of substitution between labor and capital is constant at one, defined by the sum of β and

[9] For a lively recount of the "discovery" of the Cobb-Douglas production function and the subsequent discussion see Douglas (1976) and Samuelson (1979), who was a student of Paul Douglas.

[10] Samuelson (1979) explains at length how Douglas has been confused with Wicksell and Wicksteed and that indeed Wicksell should be given credit to introducing this function. Some notes about the Wicksell's and Wicksteed's ideas on the distribution of income can also be found in the appendix of Hicks (1932)

$1-\beta$. The attribute of linear homogeneity and thus constant returns to scale implies that the revenue of total production can be exactly divided across inputs by their marginal production elasticities. Thus, under perfect competition, the labor share is defined as $s_L^{CD} = \beta$. The constant income share implies that the input ratio will always adjust to the input price ratio in such a way that the income share remains constant. It also means that the wage bill will increase at the same rate as productivity so that the wage bill, the numerator of the labor share, will increase at the same rate as output, the denominator of the share.[11]

Having matched the data to a production function Paul Douglas and his colleagues continued to assess other datasets in order to confirm the validity and somewhat the universality of the linear homogeneous production function. Next to analyzing time series by OLS, Douglas also introduced cross sectional data analysis (Samuelson, 1979). For a whole range of countries, mostly Anglo-Saxon countries, the function $Y = bL^{\beta}K^{j}$ was estimated. Douglas (1976) cites many of these studies where the authors find constant returns to scale so that $\beta+j$ approximately equal one. The estimated production elasticity of labor (β) varied, but was apparently close to the observed labor share. Although Douglas (1976) does not address the causes of the different production elasticities across industries or countries, he already mentions in Cobb and Douglas (1928) the possibility of changing production elasticities across time.

There have been some critics of the Cobb-Douglas function and the finding of constant income shares. Solow (1958a), Denison (1954), and Kravis (1959) discuss the fact that observed income shares on industry level are not necessarily constant. They argue that due to shifts in the weight of the industries within national income the overall labor share remains roughly stable. Solow (1958a) claims that one should not build a theory on the single value of the overall labor share, but should aim at explaining the underlying movements on the lower levels of aggregation. Nevertheless Solow employed the Cobb-Douglas function and the notion of constant income shares when he introduced his seminal paper on technical progress (Solow, 1957, 1958b).

Following the criticism and the new concept of the elasticity of substitution, Arrow et al. (1961) introduce a class of production functions which nests the Cobb-Douglas function as well as the Leontief production function (or Walras-Leontief-Harrod-Domar assumption of constant input coefficients, as it is called in Arrow et al. (1961)). The

[11] Bronfenbrenner (1971, chapter 16), also a student of Douglas, discusses the Cobb-Douglas function in the light of the Marshall-Hicks laws of demand and statistical evidence intensely and relates it to other theories introduced afterwards.

Constant-Elasticity-of-Substitution (CES) functions is defined as follows:

$$Y = \gamma \left[\delta K^{-\rho} + (1-\delta) L^{-\rho}\right]^{-\frac{1}{\rho}}, \tag{2.13}$$

where Y is again output, L is labor, and K is capital. γ is the efficiency or level parameter, δ the distribution parameter, and ρ the substitution parameter. The Cobb-Douglas production function is nested in it in such a way that $\rho = 0$ implies an elasticity of substitution (σ) of one. Arrow et al. (1961) show that the labor share of the CES function is

$$s_L^{CES} = \frac{wL}{Y} = (1-\delta)^{\sigma} \left(\frac{w}{\gamma}\right)^{1-\sigma}. \tag{2.14}$$

Estimating a log-linearized version of this for US non-farm production data, Arrow et al. (1961) find an elasticity of substitution smaller than one. Arrow et al. (1961) try to explain why the labor share in some US industries remains constant while there is an observed increase in the capital-labor-ratio and thus an increase in wages. Under the assumption of a unit elasticity of substitution, the input-ratio would always be adjusted to changes in the relative input prices in such a way that the income shares remain constant. With the CES function, Arrow et al. (1961) claim that there are two countervailing effects: first, the labor share should increase, since the relatively increasing input has a decreasing income share if elasticity of substitution is between zero and one. This effect is then offset by neutral technological change which dampens the rise in the labor share and keeps it roughly constant. Defining the parameters it is possible using the CES function to assume movements in technology and relative input prices which affect the labor share in a way that it is constant on the aggregate, but does not necessary demand an elasticity of substitution of one.

Christensen et al. (1973) derive yet another production function, the translog production function. The function build around a production frontier by a second-order logarithmic taylor-approximation of a function $F = f(Y, X) = 0$, where Y is a vector of outputs and X a vector of inputs. Input shares can be easily derived from a translog cost function under specific assumptions. Following the notation from above, (Hamermesh, 1993, pp. 40) presents the translog cost function with multiple inputs as:

$$ln\,C = ln\,Y + a_0 + \sum_i a_i\,ln\,w_i + \frac{1}{2}\sum_i\sum_j b_{ij}\,ln\,w_i ln\,w_j \tag{2.15}$$

where w_i is the price for input $i = 1, ..., N$

The two factor translog cost function with capital and labor is as follows

$$ln\ C = ln\ Y + a_0 + a_1 ln\ w + (1 - a_1)\ ln\ r + \frac{1}{2} b_1 \left(ln\ w\right)^2 + b_1 \left(ln\ w\right)\left(ln\ r\right) + \frac{1}{2} b_1 \left(ln\ r\right)^2$$

Assuming that the cost function is linear homogeneous in the input prices and applying Shepard's Lemma, the labor share is a function of the input prices:

$$s_L^{translog} = a_1 + b_1\ ln\ w + b_2\ ln\ r \tag{2.16}$$

The translog cost function approach to determine factor shares is often used in cases where there are more than two inputs such as capital, labor, and intermediate inputs as in Adams (1999), or in the analysis of capital and different labor inputs like skilled versus unskilled labor (Berman et al., 1994; Machin and Van Reenen, 1998; Chennells and Van Reenen, 1999; Caroli and Van Reenen, 2001; O'Mahony et al., 2008). Here the distribution of total income among multiple inputs can be easily analyzed. The factor specific input share is then Hamermesh (1993, p. 40):

$$s_i^{translog} = a_i + \sum_{j=1}^{N} b_{ij}\ ln\ w_j,\ i\ =\ 1, ..., N. \tag{2.17}$$

2.4 Theory of Growth and the Labor Share

The constancy of income share has played a large role in shaping the ideas about growth and is a fundamental part of neoclassical growth theory pioneered, as mentioned above, by Solow (1958b) and Swan (1956). Jones and Romer (2010) describe the influence of Kaldor (1961) and his so known *Kaldor Facts* on the Solow-Swan neoclassical growth model. The fifth Kaldor Fact states that the income shares are stable which relates to Kaldor's quote of the beginning of the section. This is taken into account by the neoclassical growth model. In this model all quantities grow at the same exponential rate[12] in the steady state and thus the income shares remain constant. Technological progress is typically modeled as being Harrod-neutral in growth models. Uzawa (1961) formulates this kind of growth with a similar functional setup as used above for the labor demand analysis and shows that technical progress must be labor augmenting in the steady-state, and thus Harrod-neutral, in order to keep functional income share constant.[13]

[12]Cf. Jones and Scrimgeour (2004).

[13]Drandakis and Phelps (1966) discuss the necessity of the assumption of a Harrod-neutral growth paths and the constancy of the labor share in the neoclassical growth model. Hahn and Matthews

The analysis above is focused on the available technology and how this determines the labor share. Growth theory includes macroeconomic variables such as investments, savings or consumption in their analysis next to technology. Here it is always important that capital is accumulated while labor is not. Bertola et al. (2006) devote a chapter on the functional income distribution in macroeconomic growth theory.[14] Based on Bertola et al. (2006) Bertoli and Farina (2007) describe recent theories concerning the labor share and empirical work with a focus on growth theory. These articles explain how income shares in the Post-Keynesian growth theory introduced by Harrod and Domar[15] amend aggregate saving such that an equilibrium is reached. In these models the distribution of income is determined by fixed-coefficients-technology, fixed savings rates and exogenous growth rate. The neoclassical growth model by Solow assumes the possibility of changing capital-output ratios. Under exogenous technical progress Bertola et al. (2006) show that the steady-state capital share depends on the rate of technical progress and the savings rate. Furthermore under a constant balanced growth path the income shares remain constant as well while they will be higher under a regime with a higher capital share. Bertola et al. (2006) cites also the newer strand of literature, endogenous economic growth which has strong implications on the distribution of income.[16] The main assumption of this literature is that on the aggregate production level there exist increasing returns to scale. Under these circumstances the sum of the wage bill and the capital bill exceed total output if factors are remunerated by their marginal product. Markets therefore cannot be perfect. Bertola et al. (2006) and Bertoli and Farina (2007) stress that this leaves the opportunity for political interventions into the markets and for non-market processes which determine the distribution of income across factors which differs from the rule of input price equals marginal product. These interventions will influence savings and investment behavior, the growth path and clearly share of labor income of total production.

Young (2010) revisits Solow (1958a) and discusses different long-run dynamics of the labor share on the industry level and the aggregate. He proposes several different growth models which are unbalanced and can thus incorporate different labor share behavior

(1964) survey the neoclassical growth theory and the contributions by Uzawa (1961) and Solow (1999) provides a proof. Jones and Scrimgeour (2004) give discussion and interpretation of the Uzawa (1961) work. See Acemoglu (2003b) for a more recent discussion of labor and capital-augmenting technical change and their impacts in the short and long-run on growth.

[14] Chapter 4, "Factor Income Distribution" in Bertola et al. (2006). See also Bertola (2000), chapter 2.2 for a shorter description of the main ideas on functional income distribution and economic growth.

[15] Harrod (1939) and Domar (1946).

[16] See Bertola et al. (2006), p. 79, for a list of articles dealing with this topic or Romer (2001), Chapter 3.

of industries within one economy. The models he proposes have in common that some in industries labor share and/or the relative price of one input increases continuously while the labor share in another industry or the other input's price decreases. The models are such that on the aggregate the labor share remains constant as if to fulfill Kaldor's fact.[17] Similarly Ngai and Pissarides (2007) present a growth model with an aggregate Cobb-Douglas production function, while structural change is taking place on the industry level. Here employment moves across sectors following heterogeneity of TFP across sectors. They show an economy on a balanced growth path while the employment share changes across industries. Acemoglu and Guerrieri (2008) discuss the validity of constant share under a non-balanced growth path. Here, differences in the sectors are due to differences in the supply of capital and thus differences in the capital-labor ratios. Valentinyi and Herrendorf (2008) determine the capital shares by industry in the US for multi-sector growth models and find differences in the shares across sectors.

Interpreting the labor share in a growth framework always leaves the question of whether the observed data reflects a steady state or a transition phase. This is especially interesting if one also wants to interpret country differences. With country differences under neoclassical growth analysis the countries are either in different stages of the same growth path with the same steady state defined by the capital output ratio or technology differs and the steady state varies between countries. As discussed by Bertola et al. (2006) market interventions under aggregate increasing returns to scale leave differences in institutions as an explanation for differences between countries.

2.5 The Labor Share Over the Business Cycle

Even though the labor share has traditionally been seen as relatively stable over time, there is also a consensus from business cycle research that the share behaves countercyclically to output. Returning to figure 2.2, cyclical movements around a trend are observable for the US, especially until the mid 1990s. The analysis by McDonald and Solow (1981) starts with the observation of wages and employment over the business cycle. They observed that wages remain fairly unaffected by business cycle movements while there are changes in employment. Hansen and Prescott (2005) discuss macroeconomic dynamics in the light of countercyclical labor shares in the US between 1954 and 1993. While these detailed observations are mainly based on data of the US, the European Commission (2007) cite detailed business cycle behavior of the labor share

[17] Most prominently Young (2010, pp. 100-101) discusses Kongsamut et al. (2001) and earlier versions of Acemoglu and Guerrieri (2008) and Zuleta and Young (2007).

for European countries. Countercyclical movements of the share can be confirmed for all countries, but Germany. Choi and Ríos-Rull (2009) and Ríos-Rull and Santaeulàlia-Llopis (2010) summarize the behavior of the labor share in the short-run such that it is relatively volatile, countercyclical, highly persistent, lagging output and overshoots the initial loss after a positive technological shock. A set of papers analyze the movements of the income shares over the cycle in dynamic general equilibrium models and come to the conclusion, similarly to the endogenous growth literature, that there have to be rigidities in the markets which keep prices and volumes from adjusting to shocks immediately and perfectly. Gomme and Greenwood (1995) and Boldrin and Horvath (1995) introduce labor and insurance contracts into the market which enable risk sharing between workers and firms. Young (2004) introduces biased technological change in order to explain the countercyclical behavior of the labor share. These analyses have in common that there is friction in markets or adjustments in the short-run, but in the long-run the labor share remains roughly stable. Bentolia and Saint-Paul (2003) argue that changes in the product market markups, which occur due to imperfect competition, may cause a cyclical movement of the labor share as they fluctuate over the business cycle. A procyclical markup in the product market may cause countercyclical shifts in the labor share. In several approaches for the analysis of business cycles, wages are not determined by their marginal product, but by a bargaining process. In the search and matching literature this is often done by introducing bargaining of workers and firms over wages and employment (Pissarides, 2000). Choi and Ríos-Rull (2009) introduce a Real Business Cycle Model with search frictions and a non-competitive labor market, where wages and hours are bargained over. These rigidities lead to wages that exceed the marginal product of labor while employment remains fixed due to the search frictions. This leads to a sluggish, countercyclical behavior of the share. Similar to the idea of inducing sticky wages into a model through implicit contracts by Boldrin and Horvath (1995) and Gomme and Greenwood (1995), Reicher (2011) shows how staggered wage setting in a search and matching model can induce a countercyclical labor share. Reicher (2011) suggests that only a subset of workers and firms bargain over wages at each point in time so that wages cannot be adjusted immediately after an increase in productivity. After such an increase prices and productivity go up while there is only a sluggish adjustment of aggregate wages. The labor share is therefore countercyclical. Recent contributions in this literature aim at explaining changes of business cycle movements of the labor share over time. Galí and van Rens (2010) explain the decreasing procyclicality of labor productivity (PY/L) in the US with a reduction in labor market frictions. As this is inversely related to the labor share, it implies a decreasing countercyclical movement of the labor share. This is analyzed in an empirical application by Morin (2011) who explains the decreasing countercyclicality of the labor share with decreasing union power.

2.6 Medium-Run Changes

As the labor share was mostly believed to follow Kaldor's stylized fact of constant labor shares (Kaldor, 1961), there was only little research on the longer-run movements of the labor share until the mid 1990s. Atkinson (1997) writes on the subject of factor shares: "The share of wages, and whether it is constant or rising or falling, was once a central topic in macroeconomics. As a student in the early 1960s, I listened to debates about different theories of distribution [...]. Now, thirty years later, things seem to have changed, and factor shares are not essential to macroeconomics." (p. 207). Atkinson (1997) continues on and reviews standard macroeconomic textbooks, which mostly quote the constancy of the labor share, and the usage of the E25 JEL-code (aggregate factor distribution) and comes to the conclusion that the topic has been neglected. At the same time, significant movements of the labor share, especially in Continental Europe, started the discussion on the topic again.

Poterba (1998) analyzes the income shares from the late 1950s to 1996. While finding only very little change, which can mostly be attributed to business cycle movements in the labor share, he highlights the differences of labor share movements across G7 countries. In his sample labor shares in Continental Europe decreased since the 1970s while the shares slightly increased in Canada and the UK. Observations by Poterba (1998) and others led to a new discussion trying to understand why labor shares decrease in Continental Europe and why the recent trends seem to vary across developed countries.[18] Taking into account the literature mentioned in the previous parts of this review there are several factors which can lead to a continuous change of the labor share. The first factors could be purely technical: There could be a change in the sectoral composition of the economy which was mentioned in the analysis of the labor share in the short-run or the production technology itself could change over time. As discussed in subsection 2.4 for the theory on economic growth, technical progress is a crucial determinant of growth and the division of income. Changes in technology could, for example, manifest themselves in changes in the elasticity of substitution between the input factors. These sources of change keep the neoclassical assumption prices equal to marginal costs.

[18] Extensive analyses of the behavior of the labor share in EU countries can be found in European Commission (2007) and Arpaia et al. (2009). Rodriguez and Jayadev (2010) and Jayadev (2007) provide evidence of decreasing labor shares around the globe, including developing countries.

Acemoglu (2002a) argues, for example, that firms may invest into creating a technology which is biased towards one input factor if the relative input price of this factor is much lower. If markets are not perfect, as assumed by some endogenous growth theories, profits and markups may be observed in markets. How these are distributed among factors is not fixed. Labor and product market institutions will have an influence on the sharing of economic rents between the factors of production. A change of institutions will therefore most likely influence the labor share. A last factor that is often cited in influencing the labor share is increasing globalization. International trade should lead to a decrease in profits as competition increases but also to factor price equalization if factors and production are mobile and homogeneous across countries. Several studies have investigated individual or combinations of these factors on changes in the functional income distribution and will be reviewed below.

2.6.1 Sectoral Composition and Technological Change

As mentioned in previous parts of the review several researchers have analyzed the distribution of income by looking deeper into its composition across sectors. Solow (1958a) and recently Young (2010) remarked the stability of the US labor share while the sectoral composition underlying the aggregate distribution is much less constant. Beck (1958) and Denison (1954) discuss the aggregate implication of sectoral movements across the US business cycle. Therefore an obvious explanation for changes in the aggregate labor share in Continental Europe could be sectoral change where industries with traditionally lower labor shares rise in their share of value added. de Serres et al. (2002) check this hypothesis for five European countries and the US. Adjusting the share of value added they find that most changes in France, Italy, and the US can be accounted for by sectoral change and for Germany they find that the downward trend in the labor share is fully explained by a shift towards industries with lower shares. Their explanation is a structural change where manufacturing accounts for less in aggregate value added while the relative value added in services increase. Garrido Ruiz (2005) similarly estimates the sectoral changes for Spain and also finds it to be the dominant factor for changes in the aggregate labor share. Arpaia et al. (2009) make a shift-share analysis for 15 European countries. Although they find sectoral change to be a significant source of changes in the labor share, they show that the extend to which this holds for individual countries depends also very much on the time frame of interest. In the German case, for example, they find the offsetting effects of sectoral change and within-industry change only until 1995. The largest change afterwards is due to changes in employees' remuneration. Nevertheless, they show that, except for very few cases, sectoral change had a decreasing and significant impact on the labor share in Europe since 1970. Similarly Lawless and Whelan (2011) show that as within-industry changes in employment and labor income are present, structural change cannot be the single answer to the question why the labor share changes its medium run trend in European countries. Therefore other approaches need to explain the within-industry changes.

Lawless and Whelan (2011) suggest that technological change is the driving force behind the decreasing income share of labor in Europe. As stated above, traditionally technological progress which enables long term growth is thought to be labor-augmenting ("'Harrod-neutral"'). Arpaia et al. (2009) argue that one reason for the shift in the income distribution is capital-augmenting technological progress. In their analysis, they also include two kinds of labor: skilled and unskilled workers. In addition to capital-augmenting technological progress they find differences in the elasticity of substitution between the two kinds of labor and capital to be changing the income shares. They follow a common argument that unskilled labor is a substitute to capital while skilled labor and capital are complements. With an increasing capital stock it is not clear whether the positive impact of the complementarity between skilled labor and capital or the substitution with unskilled labor dominates the shift of the labor share. The European Commission (2007) estimate the impact of several possible influences to the labor share on the aggregate level and for individual skill groups. They include two different kinds of capital: fixed capital and usage of information and communication technology (ICT). For both kinds of capital they find complementarity with high and medium-skilled workers and substitutability with low-skilled workers. The overall impact on the labor share is positive for fixed capital while it is insignificant for ICT use.[19] Large positive and significant overall correlations of the labor share and capital are also found by Checchi and Garcia-Penalosa (2010). Guscina (2007) has similar results with respect to capital and ICT and discusses additionally a structural break in 1985 for OECD countries. She claims that it is likely that before the computer revolution technological progress was labor augmenting, but turned to be capital augmenting in 1985. With a shorter dataset Jaumotte and Tytell (2008) can only confirm the differences of the elasticity of substitution by skill and find no significant overall impact of technology on the labor share. Evidence for capital-augmenting technological progress is also found in an empirical study by Bentolia and Saint-Paul (2003).

In these articles technological change happens exogenously. Acemoglu shows in several papers why and how technological change might be directed towards labor or capital

[19] There is a large literature on the impact of technological change on the income distribution with respect to skill. A review can be found in part III of Braun et al. (2009)

saving technology.[20] Similarly to Caballero and Hammour (1998), Acemoglu (2002b) shows in an endogenous growth model how firms employ less labor after a wage shock but cannot lower the labor share in the short run due to the elasticity of substitution. The factor prices invoke technological change which is labor-saving and therefore reduces the labor share. Acemoglu (2003b) introduces another endogenous growth model with endogenous technological change where firms can invest in either capital- or labor-augmenting technological progress. Depending on the elasticity of substitution between capital and labor exogenous shifts in the factor income distribution can have adverse short- and medium-run effects. In the long-run equilibrium, technological progress is always labor-augmenting and the factor shares remain stable.

Blanchard (1997) discusses the possibility of changes in technology to be a driving force for the movements in labor shares. The general argument he poses against this hypothesis is that the developed countries are too similar and close to the technological frontier such that large differences in the evolution of labor share should not be observable. Considering the almost stable labor share in the US and UK there would have to be some other differences than technology that can explain the differences to Continental European in trends. Therefore he argues for a cause connected to institutional settings in Europe which will be addressed next.

2.6.2 Noncompetitive Wage Determination

Since the 1960s most studies concerning factor shares have been nested in the neoclassical production approaches. Generally it has been assumed that output is attained through a Cobb-Douglas, CES or similar production functions. The literature adopts the view that labor demand is determined by the marginalists' perspective, but wages do not necessarily have to equal labor's marginal product. There can be mechanisms which can set wages above the marginal product, such as union bargaining. Thus, with more general production functions, such as the CES, and through introducing mechanisms which set wages higher compared to the marginal product of labor, different income share movements can be explained.

Blanchard (1997) addresses these facts in combination with unemployment. He looks at the differences and sources of the medium-run movements of the capital share and unemployment in Continental Europe and Anglo-Saxon countries. While the capital share and unemployment increased in Continental Europe since 1980, they remained relatively stable in the Anglo-Saxon countries. For Europe, Blanchard (1997) discusses

[20] Cf. Acemoglu (2002b), Acemoglu (2003b), or Acemoglu (2003a).

an adverse supply shift in the 1970s which is followed by an adverse labor demand shift in the 1980s. While he claims that the adverse supply shift, i.e. higher wages at a given level of unemployment, was due to a productivity slowdown to which wages did not adapt quickly, he examines several potential reasons for the later labor demand shift. He describes the adverse demand shift as decreasing real wages at constant input shares and productivity. The two reasons analyzed are changes in the distribution of rents between labor and capital and labor-saving technological change. Using a model of monopolistic competitive firms, Blanchard (1997) shows how an adverse supply shift can decrease the capital share while raising unemployment and then how an adverse labor demand shift can increase the capital share and the unemployment rate simultaneously.

More precisely, Blanchard (1997) first finds a shift in the relation of relative inputs and relative input prices. A primary reason for a shift in this relationship is a shift in the distribution of rents across labor and capital. He therefore assumes that there are rents and markups in the market. He dismisses the idea of increasing markups in the product market as the competition in Europe has intensified at the time due to increasing trade. He believes that a markup can only come from markups in the labor market and therefore argues that wages are not equal to marginal productivity of labor. Blanchard (1997) describes how changes in labor market institutions, such as a decreasing bargaining power of labor due to decreasing union power, can decrease markups on wages.[21] As another explanation of decreasing markups on wages, Blanchard (1997) mentions that possibly firms reduce labor hoarding (or featherbedding) as unions become less powerful. Firms might have employed so many worker such that the last worker's marginal product lies below his wage. Then a decrease in union power may enable the firms to reduce the excess employment and thus decrease the markup on wages. The second proposal for changes in the relationship between relative wages and input factors is a labor-saving technological change which implies a change in the production function. He questions this proposal as there needs to be a reason why countries with the same distance to the technological frontier, such as Anglo-Saxon and Continental European countries, should adopt fundamentally different production processes. Blanchard (2006) returns to this analysis and still finds the problem to be largely unexplained, although he still argues that changes in labor market institutions are the first candidate explanation. Notably, he is puzzled by the differences in the late evolution of unemployment in countries with the same history of decreasing labor shares since the 1980s, such as France with still high unemployment and the Netherlands with lower unemployment.

[21] Blanchard (1997) revers to "efficient bargaining" which was introduced and formalized by McDonald and Solow (1981) and will be explained below.

There is a large strand of literature exploring different mechanisms how firms and workers negotiate wages. McDonald and Solow (1981) present and model two common approaches: the right-to-manage model[22] and the efficient-bargaining model[23], which Blanchard (1997) referred to.

In the right-to-manage model the union sets wages subject to maximizing their members total utility and the firm decides on the level of employment accordingly. The firm maximizes its profit subject to the exogenous wage. Thus, the wage-employment pair lies on the firm's labor demand curve. This ensures that the firm employs so many workers such that the workers marginal productivity equals the wage rate. This works analogously to a monopoly in the product market, which sets the price of a product according to the consumers' product-demand function. In figure 2.4 the labor demand curve is depicted by L^d. Following Cahuc and Zylberberg (2004), pp. 393-405, the wage in the right-to-manage solution solves the following problem:

$$max_w \left[R\left(L^d\left(w\right)\right) - wL^d\left(w\right)\right]^{1-\gamma}\left[\left(u\left(w\right) - u\left(\overline{w}\right)\right)L^d\left(w\right)\right]^{\gamma} \tag{2.18}$$

w, the wage, solves the Nash-product of the net gains of the firm and of the worker. The firm's surplus is the revenue given labor demand, $L^d(w)$, of the firm at the given wage, $R\left(L^d\left(w\right)\right)$, minus the wage bill. The workers gain's are the utility of the worker at the wage w minus the utility the worker would receive from an alternative income at the outside option, $\overline{w}$. The individual utility surplus is multiplied by the amount of workers who are taking part in the bargaining. The Nash-product is weighted by the bargaining power of the worker, γ, and the firm, $1-\gamma$.[24]

McDonald and Solow (1981) show that the wage-employment outcome in the right-to-manage model is not efficient. The firms and the union can improve the outcome by choosing Pareto-superior points in the wage-employment plane. These points are characterized by reaching at least the same revenue level for the firm and a wage-employment pair which reaches a higher indifference curve of the union. The union's utility function and thus its indifference curves depend on its preferences for wages and employment. The Pareto-efficient points that can be reached by bargaining are therefore found on a contract-curve, which is defined as the tangency-points between the isoprofit-curves of

[22] McDonald and Solow (1981) calls this the Monopolist-Union model while MaCurdy and Pencavel (1986) refer to it as the Labor-Demand-Curve-Equilibrium model.

[23] MaCurdy and Pencavel (1986) refer to it as the Contract-Curve-Equilibrium model.

[24] For an extensive derivation of the labor share under different bargaining regimes under CES production technology, multiple input factors and market rigidities see Arpaia et al. (2009). Checchi and Garcia-Penalosa (2010) derive their predictions for their estimations from a right-to-manage bargaining model over low-skilled wages which they combine with efficiency wages for high-skilled workers.

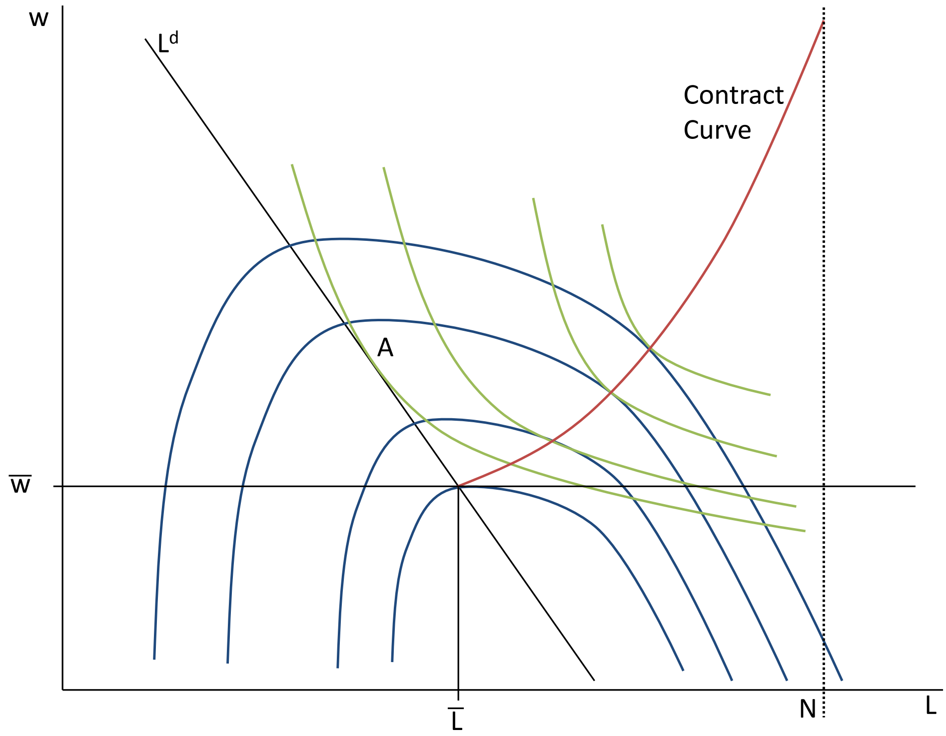

Figure 2.4: Bargaining in the Labor Market, Source: Based on McDonald and Solow (1981, p. 901)

the firm and the union's indifference-curves. These points can be found in the model of efficient bargaining, where firms and unions bargain over wages and the level of employment simultaneously. As the wage-employment outcomes are not located on the labor-demand curve any more, the wages are above the workers' marginal product of labor.

In figure 2.4 the iso-profit curves are the blue lines and the union's indifference-curves are green. Under the right-to-manage model the bargaining outcome would lie in point A, as this point on the labor demand curve reaches the highest possible indifference curve of the union. The contract curve, the brown line, starts in the point where the labor demand curve offers the wage of the outside option. It then moves to the north-east of the figure to higher indifferent-curves of the union and to lower isoprofit-curves. All points on the contract curve, except $(\overline{w}, \overline{L})$, show a bargaining outcome, where the wage lies above the marginal product of labor.

Cahuc and Zylberberg (2004), pp. 393-405, define the objective function of the efficient bargaining model as

$$max_{w,L}\ [R(L) - wL]^{1-\gamma}\left[(u(w) - u(\overline{w}))L\right]^{\gamma} \tag{2.19}$$

A general point in the case for efficient bargaining is, that outcomes off the labor demand curve and on the contract curve can only be reached if there are some kind of quasi-rents or profits that can be bargained over. The further up the wage-employment pair lies on the contract curve (higher indifference-curve for the union) the larger is the share the workers receive from these rents. The highest wage-employment pair that can be reached on the contract curve lies on the zero-profit-curve of the firm. In this case all profits will be allocated to the workers and beyond this point the firm would have to shut down. How the profit is eventually shared, or how far the bargained outcome is on the contract curve and away from the labor demand curve, depends on the bargaining power of the firm.

Returning to the arguments of Blanchard (1997), the efficient bargaining model shows how firms can be forced by strong unions to employ workers such that the workers' wage exceeds the marginal product of labor. If the bargaining power of workers decreases, the bargained contract would lie closer to the labor demand curve and thus the labor share would decrease. There are some empirical studies for single US industries analyzing how close bargained contracts are to the labor demand curve. Dickens (1995) reviews a range of empirical articles and comes to the conclusion that bargained wages are close to the labor demand curve and are thus close to the marginal product of labor. MaCurdy and Pencavel (1986) find, on the other hand, bargained wages to be on the contract curve for bargains with the International Typographical Union between 1945 to 1973 and see this as a confirmation that the efficient-bargaining model is close to actual negotiations. This is similar to the estimations by Abowd (1989) who finds strong evidence for the efficient bargaining in US collective bargaining agreements between 1976 and 1982. Manning (2010) surveys empirical evidence on bargaining outcomes and quotes the estimated rent-sharing. The estimations rage from close to zero for the rent of the worker to up to 76 percent. Although Manning (2010) discusses several sources for possible inaccuracies for the individual estimations, the results still show that there is room for bargained profits and hints on wage agreements where wages exceed the marginal productivity of labor. This implies that unions may indeed have bargaining power over wages *and* employment and therefore the level of bargaining power has an influence over the size of the labor share.

Bentolia and Saint-Paul (2003) argue that as long as workers are paid by their marginal product there is a direct relationship between the capital-output ratio and the labor share, defined by technical parameters of the labor demand elasticity. In an empirical analysis they estimate which factors could lead to a departure from the direct relationship and induce a gap between the marginal product of labor and real wages. Next to capital-augmenting technological progress they find labor adjustment costs and bargaining power of the workers as significant influences on the development of the labor share in OECD countries on an industry level. Their results on labor market institutions should be taken with care as they are both measured with proxies. Adjustment costs is measured with averages of employment growth by industry and bargaining power by an average over the adjusted conflict rate. Nevertheless, Bentolia and Saint-Paul (2003) reach the conclusion that their results on bargaining power indicates that bargaining tends to follow a right-to-manage model rather than an efficient bargaining allocation.

Some articles combine the influence of technological progress discussed above and labor market institutions on the labor share. Employing a search-model Hornstein et al. (2007) describe the impact of the combination of capital-augmenting technological change and institutions such as unemployment benefits or firing costs. In their model the institutions enhance the labor-saving technological change and reduce the labor share. Following the model by Hornstein et al. (2007), Ellis and Smith (2010) argue that technological advances and increasing usage of ICT in production improves the bargaining power of the firms in markets where wages are not payed by their marginal product, but are bargained over. Due to higher bargaining power the share of labor income in total output will decrease and find a new stable equilibrium at a lower level. Bental and Demougin (2010) approach the observation of decreasing labor shares with a principal agent framework. In their model technology is Harrod-neutral, but due to exogenously improving ICT the effort of workers is increasingly observable. If workers' effort is unobservable the workers receive a rent in the principal agent framework. The wage is then higher than the marginal product of labor. If effort becomes observable the incentives can be reduced and as monitoring improves wages approach the marginal product of labor. Given the same amount of labor the share of labor in total output therefore decreases. Similar to this, Checchi and Garcia-Penalosa (2010) introduce a derivation of the labor share with two types of workers, where the low-skilled wage is bargained over in right-to-manage framework and high-skilled workers are payed through a contract following incentives from an efficiency-wage model. In the efficiency-wage model the workers wage is set, such that it covers the outside option and that the worker will just not shirk. The efficiency wage is set according to the probability of being caught shirking and the outside option. Beside these two influences, the efficiency-wage model has no implications on the labor share per se. In the model by Checchi and Garcia-Penalosa (2010) the overall labor share is depending on the high-skilled wage and the low-skilled wage and employment. The low-skilled labor outcome is again a function of the production technology, including the elasticities of substitution between capital and both kinds of labor as well as the elasticity of substitution between high and low-skilled work. The overall labor share is consequently a function of the technology and the outside options.

Changes in product market institutions as a driving force for decreasing labor shares is proposed by Azmat et al. (2011). They observed that in several industries, such as manufacturing and network industries, OECD countries have privatized companies and industries in the same time frame the labor share decreased. They develop a model in which a firm receives utility from profits but at the same time from employment itself. A publicly owned firm will weigh employment higher in their objective function than a privately owned firm which is more likely to maximize share holders' profits. Thus a public company will employ more workers at a given wage. Following an empirical investigation Azmat et al. (2011) conclude that reducing entry barriers and thus increasing competition in markets increases the labor share as profit due to markups in the product market decrease. The decline of state control and thus the importance of employment is a countervailing effect and decreases the labor share. Across the OECD they find privatization to account for an average of 20 percent of the decline of the labor share.

Several articles estimate the impact of a whole range of labor market institutions and product market institutions on the labor share in developed countries. Theoretically the sign of the impact is not clear. Institutions designed to increase wages or employment may be successful in increasing the labor share in the short-run, but it may also be an incentive to substitute away from labor. The pace at which substitution is possible would depend on the short- and long-run elasticities of substitution between the input factors. A classical proxy for the bargaining power of workers is union density. In Jaumotte and Tytell (2008), Guscina (2007), and the European Commission (2007) the overall impact of union-density on the labor share is insignificant, while it is not robust in Checchi and Garcia-Penalosa (2010). Decreasing union density therefore seem unlikely to have caused the declining labor share. The European Commission (2007) split their results for different skill levels and find a negative impact of union density on the low skilled wages share and positive impacts on medium and high-skilled wage shares. Although this hints at diverging wages across skill groups, Checchi and Garcia-Penalosa (2010) find classical wage compression when union density is regressed on the 90/10 wage differential. Checchi and Garcia-Penalosa (2010) also include bargaining coordination in their estimation and find strong positive impacts. This indicator for bargaining power thus shows hat higher bargaining power of the worker may indeed increase their share of output. Unemployment benefits seem to have a negative impact on the labor share. The European Commission (2007) finds a strong negative impact on the overall labor share and also significant negative estimates for low- and medium-skilled shares. The estimates of Checchi and Garcia-Penalosa (2010) are also negative, but not robust, while Jaumotte and Tytell (2008) have very small, but significant and negative estimates of unemployment benefits on the wage share. From a theoretical point of view this is surprising as a higher outside option of the worker should increase their share of total income. Here there seems to be a negative employment effect as workers, especially low- and medium-skilled, rather choose unemployment than working for lower wages. The European Commission (2007) shows that a minimum wage has the expected effect of increasing the labor share especially for the low-skilled. With regards to employment protection there seems no consensus in the data. While Guscina (2007) finds a labor share increasing impact, the overall impact described by the European Commission (2007) is negative. Split-up by skill groups the European Commission (2007) shows that employment protection lowers low- and medium-skilled workers labor shares while it increases high-skilled shares. As the results on the impact of labor market institutions vary by policy and dataset there is no general conclusion if labor market liberalization would increase or decrease labor's share of income.

2.6.3 International Trade

Next to the computer revolution and liberalization of labor and product markets in Europe, international trade picked up over the same time frame. International integration of product and capital markets affect the individual factors of the determinants of the labor share in various ways. Generally increasing trade should intensify competition and thus should decrease markups and profits. As mentioned by Azmat et al. (2011) and shown by Schneider (2011), the labor share increases with increasing competition on the product market. Industries are affected differently by trade openness. The respective labor share in the industries where profit margins decrease, may affect the aggregate labor share. Trade may therefore influence the sectoral shifts from high-labor share industries to more weight of low-labor share industries in value added which was mentioned above. With regards to within-industry changes of the labor share due to trade, one has to consider the influences of trade on the wage bill. Increasing trade may affect the prices of tradeable input factors such as intermediate goods. Depending on the elasticity of substitution between labor and the respective factor this may increase or decrease labor demand at given domestic wages. Furthermore, firms may offshore or outsource labor intensive production processes to countries with lower wages and consequently decrease domestic labor demand. There are many studies concerning the impact of trade openness on wages[25] or employment/unemployment[26].

Several studies have investigated the impact of trade openness on the overall labor share. Harrison (2002) uses a Nash-Bargaining approach to derive theoretical implications of trade on the labor share. She finds that the domestic labor share should rise if: (1) the foreign wage premium rises, (2) the foreign premium to capital falls, (3) the fixed cost to capital of reallocation rise, (4) the fixed cost to labor of reallocation rise. Estimating the impact of openness on the labor share for developed and developing countries she concludes that government influences, such as government spending and capital controls, increase the labor share, while increasing trade shares, foreign direct investment inflows and exchange rate crises decrease the labor income shares. Including an outside option of the firm to an efficient bargaining approach Jayadev (2007) models the possibility of a firm to reallocate capital to other countries for production. This should have a negative impact on the domestic labor share. He confirms this hypothesis empirically in a large country panel for high- and medium-income countries. In a theoretical model Pica (2010) comes to a similar conclusion. He analyzes the impact of capital market integration on the labor share and lifetime utility in a two country overlapping-generation model. Capital market integration decreases the labor share of income which decreases capital accumulation. The overall impact on workers' labor market outcomes is unclear. Guscina (2007), Jaumotte and Tytell (2008) and the European Commission (2007) show in their empirical analyses that trade openness ($imports + exports/value\ added$) and offshoring decreases the labor share. The estimation results of European Commission (2007) imply that the negative impact of openness is fully absorbed by medium-skilled workers. While high- and low-skilled workers seem unaffected by increasing trade medium-skilled workers' wage bill decreases. Jaumotte and Tytell (2008) find the negative impact of offshoring to be mostly affecting high-skilled sectors, while low-skilled sectors remain unaffected. Bachmann and Braun (2011) show a higher risk of unemployment especially for medium-skilled workers due to international outsourcing in a study for Germany.

[25] Cf. to Krugman (2008) for a general discussion or Rama (2003) for estimations on the impact of trade liberalization on wages.

[26] Felbermayr et al. (2011) estimates the impact of trade on unemployment and finds openness to be unemployment reducing. Helpman and Itskhoki (2010) create a model where trade openness increases unemployment if labor market rigidities are high and decrease it if the are low. Braun et al. (2009), part II, analyze the interconnection between trade and ICT capital on employment. They show that while trade may cause workers displacement in the short-run it may enhance employment in the long-run. Furthermore the impact of trade on employment depends on the industry

2.7 Concluding Remarks

After Atkinson's remarks (Atkinson, 1997) that the interest in the labor share has disappeared, it has suddenly been addressed again by various researchers and analyzed from multiple points of view. This literature review describes the multitude of influences, such as technology, institution, or globalization, which impact the income share of labor over time. The changes are not homogeneous and vary by country, industry and characteristics of the labor force such as skills. Atkinson (2009) discusses the importance of dealing with the factor income shares in a more current article "Factor shares: the principal problem of political economy?" an concludes as follows:

> "There is a great need, particularly at this juncture, to unify the different branches of economics. The link between macro and micro is essential, and economics has suffered from allowing these to go their separate ways. Empirically, the national accounts need to be brought closer to micro-data on households. Theoretically, the aggregate analysis of distribution needs to look at both profits and the wages of heterogeneous workers. Growth theory, macroeconomics, and labour economics are all part of the mix." (Atkinson, 2009, p.15).

These words underline that there is no unifying theory or empirical approach that can simply bring out the underlying nature of factor shares. While one might argue that Kaldor's stylized fact of constant shares holds for the US and the UK, the developments in Europe still question the underlying mechanisms. A stylized fact today should be able to explain the differences in the labor share movements as well. It may be possible to find common ground on the description of the labor share for cyclical short-run movements, but there is less consensus for findings in the longer-run. As the analysis of factor income share is complex there are still many avenues for research, empirical and theoretical, for finding the influences which have a truly significant impact on the functional income distribution.

3 The Impact of ICT Investments on the Relative Demand for High-, Medium-, and Low-Skilled Workers: Industry versus Country Analysis

Abstract. In this paper I analyze the impact of investments into information and communication technology (ICT) on relative compensation shares of high-, medium-, and low-skilled workers. Next to investigating the influence of ICT in 14 countries, I explore this impact for 23 industries. I find that the skill-biased technological change hypothesis is rejected if single countries are analyzed with an industry panel, while ICT investments influence relative compensation shares in single industries. There is a positive impact of ICT on high-skilled workers' relative compensation for the time before 1995, while medium- and low-skilled workers' compensation shares are affected especially since 1995.

3.1 Introduction

Since the 1980s the compensation of high-skilled workers relative to lower-skilled workers in the US increased substantially. Such an increase in inequality was also observable in other developed countries. This phenomenon has led to an extensive literature discussing reasons for this development. Next to changes in labor market institutions (Card and DiNardo, 2002; DiNardo et al., 1996) and outsourcing (Feenstra and Hanson, 2001), the increasing usage of information and communication technology (ICT) which led to a technological change in the production process has been discussed to be the leading source of the demand shift away from lower-skilled workers towards high-skilled workers.

Lemieux (2008) calls the acceptance of the empirical finding of the demand shift towards high-skilled workers and the claim of a skill-biased technical change as the main source of this shift the "1990s consensus".[1] In the last decade shifts of the demand for medium- and low-skilled workers gained further attention as researchers found a so

[1]See also Machin and Van Reenen (2007) for a review and assessment of this discussion.

called polarization in the distribution of wages. Polarization describes the increasing wage and employment gains by high earners, which are usually high-skilled workers, and simultaneously decreasing wages and employment of medium-skilled workers who become more similar to low-skilled workers. A more recent strand of literature explains this development by the level of routine tasks performed by the worker groups (Autor et al., 2003; Spitz-Oener, 2006; Goos and Manning, 2007; Autor et al., 2006). This theory claims that medium-skilled workers tend to perform a higher share of routine tasks and are thus more easily substitutable by ICT than for example low-skilled workers with a higher share of manual tasks.

In this paper I analyze how ICT has influenced the relative compensation shares of high- medium-, and low-skilled workers in 14 industrialized countries, its impact on 23 separate industries, and how the impact changed over time. The objective of my paper is to analyze whether the impact of ICT on relative compensation by skill group is similar across countries and industries and can confirm the consensus described above. Furthermore, I investigate the development of the relationship of ICT and relative compensation shares across time. In a first step I discuss an extensive set of descriptive statistics on the development of employment and compensation shares and the investment into ICT. I then take the assumption of a skill-biased demand shift due to technological change to the data and estimate the impact of ICT investments on the relative compensation share of high-, medium-, and low-skilled workers in 14 advanced countries. The time span I analyze is much longer compared to other studies. For ten of these countries there are between 24 and 36 years available. For the remaining four countries the time span between the early 1990's to 2005 is investigated. This analysis shows for which countries the impact of ICT investments on the relative compensation shares is persistent and which skill group is gaining or losing due to the technological advances. If technological change due to the increasing use of ICT in production is the driving force behind the rising inequality and the observed polarization one would expect that ICT investments have a positive impact of the relative compensation share of high-skilled workers and a negative on medium-skilled workers' share.

My analysis also goes beyond the analysis of individual countries and investigates the impact of ICT income inequality for individual industries of the private economy. This offers new explanations for differences in the results by country other than differences in institutions. Intuitively, estimating a cost function for an industry across countries may be more sensible than assuming a single cost function for all industries within one country. Thus, in a second approach, I investigate the influence of ICT investments on the relative compensation shares in individual industries in the ten countries with the longest available time series. In contrast to former studies I do not only focus on manufacturing, but I also include services and other sectors so that the analysis covers the largest part of private economic activity. Investments into ICT have been growing in service sectors remarkably since the 1970s. My analysis closes a gap in the literature by including these sectors.

My analysis confirms a positive impact of ICT investments on the relative compensation share of high-skilled workers only for Austria, Denmark, and Korea. A polarizing impact of ICT investments through a negative impact on the medium-skilled workers' compensation share and/or a positive impact on the one of low-skilled workers are found for Austria, Germany, Italy and the US. The results by industry show that the influence of ICT investments depend on the specific industry and can be sorted into three groups. The first group, Textiles, Paper/Publishing, Chemicals, Manufacturing Nec., and Post/Telecommunication, are characterized by increasing high-skilled relative compensation shares through ICT investments, while the shares of the other skill groups remain unaffected by ICT investments. In the second group ICT investments have a negative significant influence on the medium-skilled relative compensation share and a positive on the low-skilled share. In this group ICT investments have no impact on the high-skilled share. This group consists of the industries Mining/Quarrying, Food, Rubber/Plastics, Electrical/Optical Equipment, and Transport Equipment. All other industries belong to the third group in which the relative shares are not significantly influenced by ICT-investments.

Lemieux (2008) and O'Mahony et al. (2008) discuss possible changes in the development of income inequality. O'Mahony et al. (2008) find structural changes in the impact of ICT on relative compensation shares in the early 1990s in the UK and US. I follow this finding and estimate the above mentioned analyses with the assumption of a structural break. The general picture of the results are that ICT investments influenced high-skilled workers compensation shares positively until the mid 1990's. Afterwards the impact seems to vanish. The influence of ICT investments on the medium-skilled workers compensation shares is negative while it is positive on the low-skilled workers shares for a third to half of the industries, including service industries.

In the later part of the 1990's a large literature on the impact of changing technology on relative compensation developed. (See Lemieux (2008) and Machin and Van Reenen (2007) for reviews of this discussion.) Most studies focus on manufacturing (Machin and Van Reenen, 1998; Berman et al., 1994). Data on ICT has so far not been available so that it was proxied by other variables such as R&D. My paper is close to O'Mahony et al. (2008), whose analysis goes beyond manufacturing. Furthermore, they include industries similar to those that I study. They also use a direct measure of ICT investments and analyze three (high, intermediate, low) skill groups. Nevertheless, my study is much broader as 14 countries are subject to the analysis as opposed to three in O'Mahony et al. (2008). This allows a separate analysis of individual industries. Moreover, I consider data for a longer time span. Thus, a larger time frame is available after the observed structural break in the mid 1990's. Consequently my study provides insights about the consistency of the impact of ICT on income inequality across countries and time.

The structure of the paper is as follows. The next section gives a description of the data used in this study. Section three introduces the basic economic model and the econometric methods. In the fourth section I separately discuss the results of the estimation by country, by industry and the estimation with a structural break. The fifth section concludes.

3.2 The Data

The data source of this study is the EU KLEMS dataset in its version of March 2008.[2] It is a harmonized sectoral dataset for the countries of the European Union and other advanced countries such as the US, Japan, Australia, and South Korea, with comparable data across sectors, variable definitions and time. It was designed originally to measure economic growth and productivity. Thus it includes many measures of different capital inputs as well as labor input for three skill groups as well as age and gender groups. The data originates from the individual statistical offices and was then harmonized to the same industry levels, reference years, and categorizations of capital and labor specifications by the EU KLEMS project.

The coverage varies by country, by industry and for the individual variables. The longest series cover the time span from 1970 to 2005. The variables used in this study are listed in table 3.1. The set of countries used in this study is listed in table 3.2, the set of industries is described in table 3.3. The 23 industries used here cover most of the countries' private economic activity including service sectors. Sectors which are mostly public or agricultural are left out of the analysis. Table 3.4 show the unweighted industry means by countries for the three depended and two independent variables.

[2] Detailed information on the dataset can be found on the web page www.euklems.net or in Timmer et al. (2007a).

Table 3.1: Description of Relevant Variables.

Variable	Abbreviation	EU KLEMS Description
Real Value Added	Y	$\frac{va}{va\_p} * 100$
Real Gross Fixed Capital Stock	K	k_gfcf
ICT Investments	K^{ICT}	iq_ict
Relative Compensation Shares	Share	labhs, labms, labls

Table 3.2: Set of countries analyzed in this study.

Countries	times periods
Australia	1982 - 2005
Austria	1980 - 2005
Czech Republic	1995 - 2005
Denmark	1980 - 2005
Finland	1970 - 2005
Germany	1991 - 2005
Italy	1970 - 2005
Japan	1973 - 2005
Korea	1977 - 2005
Netherlands	1979 - 2005
Slovenia	1995 - 2005
Sweden	1995 - 2005
United Kingdom	1970 - 2005
United States	1970 - 2005

Table 3.3: Set of industries analyzed in this study.

Industries
Mining and Quarrying / Food, Beverages and Tobacco / Textiles, Textile, Leather and Footwear / Wood and of Wood and Cork / Pulp, Paper, Printing and Publishing / Coke, refined petroleum and nuclear fuel / Chemicals and chemical / Rubber and plastics / Other Non-Metallic Mineral / Basic Metals and Fabricated Metal / Machinery; Nec. / Electrical and Optical Equipment / Transport Equipment / Manufacturing Nec.; Recycling / Electricity, Gas and Water Supply / Construction / Wholesale and Retail Trade / Hotels and Restaurants / Transport and Storage / Post and Telecommunications / Financial Intermediation / Real Estate, Renting and Business Activities / Other Community, Social and Personal Services

The dataset contains several capital stock variables. As a proxy for technological development ICT investments is used.[3] ICT is considered as office and computing equipment, communication equipment and software. This should be the closest proxy for the technological change described by the skill-biased technological change literature.

The relative compensation share is the shares of total compensation which is payed out to workers of a specific skill group. It is therefore “relative” to the share of the other skill groups. In this study I employ all three skill groups: high, medium and low-skilled. The shares of the three skill groups add up to one. Total compensation are all wages and salaries including all costs that are covered by the employer. This is adjusted for the share of self-employed and thus included all compensation of employees and self-employed, where it is usually assumed that workers with the same characteristics in an industry have the same wages regardless whether they are self-employed or employees. The relative compensation share therefore also include self-employed workers. The skill groups are defined by the level of education of the workers. As educational systems vary across the relevant countries the definitions of who belongs to which skill group differ slightly. The affiliation to a skill group is determined through the highest degree of the worker at time t and not the occupation. Generally, workers with a college degree are measured as high-skilled workers, workers with upper secondary education, some college or a vocational degree are counted as medium-skilled, and workers with at most secondary education or no formal qualifications are counted as low-skilled workers.[4]

[3] In the EU KLEMS this is ’real gross fixed capital formation’ of ICT assets.

[4] A detailed description of the definitions of skill levels for each country can be found in Timmer et al. (2007b), page 28.

Table 7 shows the development of the labor cost share of high-, medium-, and low-skilled workers in the upper rows on the country level. It can be seen that since 1985 the relative wage share of the high-skilled workers increased continuously. The relative employment share, which is measured in share of total hours worked by each skill group, is shown in the lower rows of the same table and mirror the development of the high-skilled wage share. Thus, also relative employment rose since 1985 for high-skilled workers. Table 8 shows the average annual growth rate of compensation and employment shares for 10 year intervals between 1975 and 2005 on the country level. Here it can also be seen that the growth rates are always positive for the high-skilled workers, but the size of the growth rates differ between time periods and countries. While in the UK, the US, Finland or Austria the growth of the compensation and employment shares of high-skilled slowed down during this time, the relative shares for high-skilled workers in Japan or Denmark had an almost constant growth over the available time period. In the other countries the growth rates increased, although much more for the high-skilled compensation shares than for the employment shares. This indicates an increase of the compensation share rather due to higher relative wages than due to higher employment.

Table 3.4: Means of Dependent Variables and Regressors by Country

	Compensation Shares				
	High	Medium	Low	$\frac{K^{ICT}}{Y}$	$\frac{K}{Y}$
overall	16.32	58.89	24.78	0.03	2.83
Australia	13.60	42.99	43.41	0.03	2.77
Austria	8.27	70.18	21.55	0.03	2.97
Czech Republic	17.96	75.68	6.36	0.10	5.42
Denmark	5.77	60.44	33.79	0.04	3.85
Finland	28.43	33.41	38.17	0.02	2.84
Germany	12.25	67.57	20.18	0.03	2.56
Italy	4.43	93.28	2.29	0.02	2.58
Japan	19.64	54.36	26.00	0.02	2.65
Korea	29.75	42.00	28.26	0.04	3.52
Netherlands	8.05	80.71	11.24	0.04	2.77
Slovenia	23.97	62.07	13.96	0.08	6.88
Sweden	12.45	61.70	25.85	0.05	2.31
United Kingdom	11.36	57.14	31.49	0.03	2.02
United States	25.96	57.90	16.15	0.01	2.50

Unweighted means of the 23 industries from table 3.3 by country.

A similar picture can be seen if separate industries are analyzed. Table 9 show the average compensation and employment shares which are measured as an average of each industry for the countries Australia, Austria, Denmark, Finland, Italy, Japan, Korea, Netherlands, United Kingdom, and United States. The data for the high-skilled workers show that also across industries the compensation and wage shares of high-skilled workers increased since 1985 for all industries. However, between 1975 and 1985 in half of the industries, some in manufacturing but also in construction or service industries, the high-skilled compensation share decreased as it can be seen in table 10. After 1985 all average growth rates for high-skilled workers compensation and employment shares are positive. The employment shares tend to be larger than the compensation shares, which again suggest increasing relative wages next to increasing employment. Especially in manufacturing industries the compensation shares for high-skilled workers increased at a higher rate since the mid 1990's compared to before.

As for the medium-skilled workers the development of their compensation shares are more heterogeneous across countries. Table 8 shows that the average growth rates of medium-skilled workers compensation shares went from positive before 1995 to negative afterwards for all countries, except for Australia, Denmark, and Finland. Although the compensation shares decreased in the latest period the employment share still increased, which implies a relative wage drop. The negative growth rates for medium-skilled workers seem mostly attributable to the service industries which follow this pattern, while manufacturing industries have positive average growth rates of medium-skilled workers compensation and employment shares.

The picture for low-skilled workers is very homogeneous. Except for Germany the employment and compensation shares of low-skilled workers decreased across all countries and all industries. Especially in the period after 1995 the drop in the compensation shares is again stronger than the drop in the employment shares. Similar to the latest development for medium-skilled workers, the low-skilled workers seem to have lost in relative wages.

The explanation for these developments analyzed in this paper is the increasing importance of ICT in the production process, which can be a complement or substitute for the individual worker groups. Table 11 shows the development of total ICT investments by country. In all countries ICT investments have increased over the available time period. In the US, Japan, and Denmark the growth rates declined over time, while for the other countries the growth rates of ICT investments continuously increased since 1975. This is not very surprising as especially the US and Japan are considered to be the frontier of ICT development and these three countries had extremely high ICT investment growth rates between 1975 and 1985. In the analysis of individual industries, the very high growth rates in the service industries are remarkable. Earlier studies usually concentrated on manufacturing. But as ICT investments have been growing substantially also in the service sectors its effects should also be analyzed in these industries. Considering the drop in the relative compensation shares of medium-skilled workers in especially these industries and the simultaneous steep growth in ICT investment, technological changes seems to be a good candidate explanation for the changes in the relative wage share.

3.3 Estimation Method

This analysis follows a standard approach to estimate demand shifts for skill groups due to technological progress by employing a share equation derived from a translog cost function (Christensen et al., 1973). The principle of duality allows a derivation of the cost share from translog cost function which based on a translog production function (Varian, 1992, Ch. 6). The translog cost function is linearly homogenous, concave in factor prices, and twice differentiable. The cost function of an industry or country i in year t is set up as[5]

$$
\begin{aligned}
ln\, C_{it} = \alpha &+ \sum_{j\in h,m,l} \beta_{ji}\, ln\, w_{jit} + \sum_{j\in h,m,l} \sum_{j'\in h,m,l} \beta_{jj'}\, ln\, w_{jit}\, ln\, w_{j'it} \\
&+ \beta_Y\, ln\, Y + \sum_{j\in h,m,l} \beta_{jY}\, ln\, w_{jit}\, ln\, Y_{it} + \beta_{K^{ICT}}\, ln\, K_{it}^{ICT} \\
&+ \sum_{j\in h,m,l} \beta_{jK^{ICT}}\, ln\, w_{jit}\, ln\, K_{it}^{ICT} + \beta_K\, ln\, K_{it} \\
&+ \sum_{j\in h,m,l} \beta_{jK}\, ln\, w_{jit}\, ln\, K_{it} + \sum_{j\in h,m,l} \beta_{ju}\, ln\, w_{jit}\, u_{jit} + u_t.
\end{aligned} \tag{3.1}
$$

Here the costs (C) are a function of the prices of the variable input, wages (w) by skill j: high- (h), medium- (m), and low- (l) skilled workers, output or value added (Y), fixed capital (K) and ICT-capital investments (K^{ICT}). u is a random error term. The function is set for time period t and for industry or country i.

Assuming homogeneity in prices, the following restrictions hold

$$
\begin{gathered}
\sum_{j\in h,m,l} \beta_{ji} = 1 \\
\sum_{j\in h,m,l} \beta_{jj'} = \sum_{j'\in h,m,l} \beta_{jj'} = \sum_{j\in h,m,l} \sum_{j'\in h,m,l} \beta_{jj'} = 0 \\
\sum_{j\in h,m,l} \beta_{jK^{ICT}} = \sum_{j\in h,m,l} \beta_{jK} = \sum_{j\in h,m,l} \beta_{ju} = 0.
\end{gathered}
$$

The function can then simplified by normalization to the low-skilled workers' wages. Applying Shepard's lemma, the translog cost function leads to the following cost share equation for high- and medium-skilled workers.

$$
share_{jit} = \alpha + \sum_{j\in h,m} \beta_{w_j}\, ln\, \frac{w_j}{w_l} + \beta_K\, ln\, K_{it} + \beta_Y\, ln\, Y_{it} + \beta_{K^{ICT}}\, ln\, K_{it}^{ICT} + \eta_{ji} + u_{jit} \tag{3.2}
$$

The relative cost shares ($share$) are a function of relative wages, value added, capital

[5]This cost function follows closely the setup of Adams (1999) and Hijzen et al. (2005) who derive the share equation in great detail. Chennells and Van Reenen (1999) and Sanders and ter Weel (2000) give overviews of this approach and review a large number of studies which have a similar setup.

stock, and ICT. η_{ji} the country-skill-specific time-invariant effect. Wages are endogenous in the econometric setup of equation (3.2), as the compensation share is defined by wages and wages appear on the right hand side as well. Estimating under endogeneity leads to biased coeffient estimates, which is usually addressed by an instrumental variable estimation. Unfortunately, for the econometric specification, there are no convincing instruments in this case. Berman et al. (1994), Machin and Van Reenen (1998), or O'Mahony et al. (2008), argue to replace wages by year dummies in the estimation of share equations across industries. These time dummies are supposed to capture the effects of relative wages and macroeconomic shocks. As a drawback they might also capture some of the variation from the technological progress, as in other studies technological progress is often proxied by a linear time trend. The estimation equation takes on the following form,

$$share_{jit} = \alpha + \beta_K \, ln \, K_{it} + \beta_Y \, ln \, Y_{it} + \beta_{K^{ICT}} \, ln \, K_{it}^{ICT} + \eta D_t + \eta_{ji} + u_{jit}, \tag{3.3}$$

where D_t represent the time dummies.

The share equation can be expressed in capital and ICT shares of total output if the production function follows constant returns to scale. The share function has mirrors the property of constant returns to scale in the production function, if the restriction in equation (3.4) holds. Then (3.3) can be reduced to equation (3.5) which depends only on the relative values of input factors to output.

$$\beta_Y = -\left(\beta_K + \beta_{K^{ICT}}\right) \tag{3.4}$$

$$share_{jit} = \alpha + \beta_{KY} \, ln \left(\frac{K_{it}}{Y_{it}}\right) + \beta_{K^{ICT}Y} \, ln \left(\frac{K_{it}^{ICT}}{Y_{it}}\right) + \eta \, D_t + \eta_{ji} + u_{jit} \tag{3.5}$$

This condition is tested and for most industries and countries the assumption that cost function exhibits constant returns to scale seem plausible. The values of the test-statistics are presented in table 13 by country and in table 14 by industry. As a rule of thumb, the hypothesis of constant returns to scale in production can be rejected on a 10 % level if the test-statistic is greater than 2.5. This is the case for only a few regressions across industries and only four countries, separated by skill group. The main focus of this paper is on the estimation of equation (3.5) with the assumption of constant returns to scale. As a robustness check, all estimations were repeated by the estimation without the assumption of constant returns to scale.

The main part of this study concerns the estimation of equation (3.5) for each country across industries and for the individual industries across countries using the fixed effects estimator. Some of these industry or country specific effects can be institutions which also influence the relative wage share of the skill groups. Therefore, the variation between the industries and countries caused by institutions is controlled for and only the changes in institution across time within industries and countries remains. [6]

O'Mahony et al. (2008) use a variation of this equation and estimate it for several skill groups in France, the UK and the US for a similar time frame. They also find structural breaks in the first half of the 1990s. Other studies mention a structural break for ICT capital between 1994 and 1995. Thus, I estimate equation (3.5) and interact the intercept, $ln\frac{K}{Y}$, and $ln\frac{K^{ICT}}{Y}$ with a dummy for the time period before 1995 and a time dummy for 1995 and after. The difference of the coefficients of the two time periods is also tested. For robustness checks and for comparisons with O'Mahony et al. (2008) the same was also done with a time break between 1990 and 1991 without large changes in the results.

In order to account for the differences in industry size and its potential to cause heteroscedasticity, each industry is weighted by its average labor costs share within the respective country across the available time frame. I have also used different alternatives to this as a robustness check. With respect to the size of the coefficients and the significance it does not matter much if the above mentioned weight is used or the labor cost share of the respective industry in specific years, such as 1982 or 1995, or if no weight is used at all. Robust standard errors correct for the remaining heteroscedasticity, and serial correlation.

[6] I repeated all estimations with the first difference estimator. This estimator hardly ever delivered significant results, which is most likely due to the estimator's properties which make it less efficient compared to the fixed effects estimator. While the standard errors grow considerably when the fixed effects estimator is used with robust standard errors as opposed to uncorrected standard errors, the cluster robust standard errors with the first difference estimator are smaller than the OLS standard errors in half of the cases. If larger lags in the exogenous regressors are implemented in the difference estimator, the results for high-skilled workers become significant for more countries and industries the larger the lag is. For eight year lags the results are most often positive and significant, but this is most likely only due to the positive correlation between high-skilled workers compensation share and ICT investments. Using an extremely long lag of 25 years, Michaels et al. (2010) find an overall positive correlation of ICT capital with high-skilled wage shares and a negative with medium-skilled shares if all data is pooled. It has to be noted that next to a slightly different subset of the EU KLEMS data, Michaels et al. (2010) differ in their estimated share function from this study. Lagged ICT investment as a regressors in the fixed effects estimation is always insignificant. Due to all these results, the fixed effects estimator seems far more suited for this study.

3.4 Estimation Results

Following the hypothesis of skill-biased technological change, the ICT coefficient, β_{KICT}, should be positive and significant when high-skilled workers' compensation shares are analyzed. The expectations on β_{KICT} are less clear for the case of medium- and low-skilled worker compensations shares. The traditional idea of skill-biased technological change implies a somewhat linear relationship between skill and the positive effect of technological change. So one would expect a negative β_{KICT} for the analysis with low-skilled workers' compensation shares, and no clear result for medium-skilled workers' compensation shares. (Braun et al., 2009, Part 3) More recent micro-level studies find a polarization of compensation shares of the skill groups.[7] In these studies it is argued that especially since the 1990s the wage shares in the middle of the wage distribution is decreasing due to ICT while the the wages of workers at the lower end of the wage distribution are not or much less affected by ICT. In those papers the line of argumentation is that the tasks of workers in the middle of the wage distribution, which are mostly medium-skilled workers, are in general more easily replaceable by ICT and that the lower end workers, the low-skilled ones, are only marginally affected by ICT due to their task structure. This implies that there is hardly an effect of ICT on the low-skilled workers compensation shares and a negative impact on the medium-skilled compensation shares.

3.4.1 Estimation Results by Country

Table 3.6 shows the results for the fixed effects estimation of equation (3.5) for the 14 countries in the sample. An overview of the qualitative results is given in table 3.5.

The results of the estimation vary remarkably across countries. Only for Australia, Denmark, and Korea the ICT coefficient β_{KICT} is the way it was expected for the high-skilled compensation shares, namely positive and highly significant. The results for Australia imply what was expected from a skill-biased linear effect of ICT on the relative compensation. Here the medium-skilled workers' compensation share seems unaffected by ICT investment, but the compensation share of low-skilled workers is negatively affected by it. In Finland the coefficient on ICT-investments in high-skilled compensation share estimation is negative and significant. ICT seems to have no significant effect on the high-skilled wage share in Austria, the Czech Republic, Germany, Japan, the Netherlands, Slovenia, Sweden, the UK, and the United States.

[7] These findings are given in the light of the task literature of Autor et al. (2003). Autor et al. (2008) find polarizing wage structures for the US, Goos and Manning (2007) for the UK and Spitz-Oener (2006) for Germany.

Table 3.5: Overview of Results for the Country Estimation

Variable	High-Skilled	Medium-Skilled	Low-Skilled
positive significant on the 10% level	Australia Denmark Korea	Finland	Germany Italy* US*
insignificant	Austria Czech Rep. Germany Italy Japan Netherlands Slovenia Sweden UK US	Australia Czech Rep. Denmark Japan Korea Netherlands Slovenia Sweden UK US	Austria Czech Rep. Denmark Japan Korea Netherlands Slovenia Sweden UK
negative significant on the 10% level	Finland	Austria Germany Italy	Australia Finland

* Here results of estimation of equation (3.3) are given as the constant returns to scale in production are rejected. See also subsection 3.4.4.

One could argue that the technologies in these countries differ and that there might be clusters of countries which are more technologically advanced and thus ICT investments have different effects on the wage shares of workers. The composition of the three groups is nevertheless surprising. Also that the coefficients in the UK and the US are insignificant is surprising when other studies are considered. For these countries studies have usually found a strong positive impact of ICT on the relative compensation of high-skilled workers (Machin and Van Reenen, 1998; O'Mahony et al., 2008).

In order to analyze whether ICT contributes to a polarization for the relative incomes by education, the estimation equation (3.5) is also estimated for medium- and low-skilled workers compensation shares. For Austria, Germany, and Italy ICT investments have a negative impact on the relative compensation share of medium-skilled workers. This can be explained if one assumes that medium-skilled workers tend to have jobs with repetitive tasks and can be easily replaced by computers. As medium-skilled workers are substitutes to computers their compensation shares decrease as ICT becomes cheaper. For half the other countries the coefficient on ICT investment of the regression for medium-skilled workers is negative, but not significant and for the other half the coefficient is positive, but insignificant. Only in Finland ICT investments have a strong positive influence on medium-skilled workers' compensation shares.

With regards to the low-skilled workers' compensation shares, the coefficient for ICT investments is positive for Germany. This is again surprising. The classical skill-biased technological change hypothesis assumes that low-skilled workers are substituted by ICT and would therefore expect a negative coefficient here. This is only the case for Australia and Finland. The task approach implies that for traditional low-skilled jobs such as cleaning or filling shelves, ICT is not relevant and would thus predict an non-significant coefficient. A positive coefficient now indicates that their work is rather complementary to ICT. For the estimation under the assumption of constant returns to scale the results remain basically the same. In Australia and Finland the impact of ICT on the high-skilled workers' compensation share is negative, while it is positive in the case for medium-skilled. The results for Finland may be explained by the nature of being a relatively small country with strong ICT-producing industry (Daveri and Silva, 2004). Production of ICT good is probably rather medium-skill intensive than the usage of them. With these characteristics, spillovers to other industries within the country and the general industrial composition of the country may drive these results.

For Austria, Germany, and Italy the results indicate that ICT seems to have a polarizing effect on the lower end of relative compensation distribution as low- and medium-skilled shares are driven together by ICT investment. Generally it is quite remarkable that these results are so heterogeneous. As these countries have all access to the same technology, it seems puzzling that ICT has such different impacts on the relative skill groups wage shares.

Table 3.6: Regression by Country

Dependent Variable: Relative Compensation Share of the Respective Skill Group			
Variable	High-Skilled	Medium-Skilled	Low-Skilled
Australia			
$ln\frac{K^{ICT}}{Y}$	4.095**	0.063	-4.158**
	(1.905)	(0.611)	(1.958)
$ln\frac{K}{Y}$	-10.21*	-3.255	13.46*
	(5.942)	(2.822)	(7.719)
N	552	552	552
R^2	0.616	0.595	0.479
Austria			
$ln\frac{K^{ICT}}{Y}$	0.059	-1.466	1.406
	(1.688)	(1.660)	(1.167)
$ln\frac{K}{Y}$	4.881	-7.440*	2.558
	(3.241)	(4.285)	(2.133)
N	598	598	598
R^2	0.494	0.538	0.870
Czech Republic			
$ln\frac{K^{ICT}}{Y}$	0.045	-0.206	0.161
	(0.331)	(0.404)	(0.142)
$ln\frac{K}{Y}$	0.931	-0.170	-0.761*
	(0.819)	(0.912)	(0.313)
N	253	253	253
R^2	0.585	0.220	0.804
Denmark			
$ln\frac{K^{ICT}}{Y}$	1.098*	-1.011	-0.086
	(0.606)	(1.588)	(1.184)
$ln\frac{K}{Y}$	-5.378***	9.143***	-3.765**
	(1.431)	(2.891)	(1.722)
N	598	598	598
R^2	0.693	0.733	0.863
Finland			
$ln\frac{K^{ICT}}{Y}$	-1.209**	2.605***	-1.396*
	(0.451)	(0.838)	(0.732)
$ln\frac{K}{Y}$	-1.666	-1.352	3.018
	(2.029)	(3.665)	(3.148)
N	797	797	797
R^2	0.895	0.828	0.972

Continued on next page

Table 3.6 – *continued from previous page*

Dependent Variable: Relative Compensation Share of the Respective Skill Group			
Variable	High-Skilled	Medium-Skilled	Low-Skilled
Germany			
$ln\frac{K^{ICT}}{Y}$	-0.189	-3.302*	3.491*
	(0.489)	(1.260)	(1.555)
$ln\frac{K}{Y}$	-0.019	1.463	-1.443
	(0.954)	(3.019)	(3.804)
N	345	345	345
R^2	0.752	0.627	0.303
Italy			
$ln\frac{K^{ICT}}{Y}$	1.499	-2.209*	0.710
	(1.291)	(1.269)	(0.585)
$ln\frac{K}{Y}$	-8.886	11.69**	-2.808
	(5.503)	(5.369)	(1.910)
N	828	828	828
R^2	0.297	0.295	0.650
Japan			
$ln\frac{K^{ICT}}{Y}$	2.753	-4.672	1.919
	(1.680)	(3.570)	(2.053)
$ln\frac{K}{Y}$	-6.775**	13.77**	-6.994*
	(2.728)	(6.386)	(3.884)
N	759	759	759
R^2	0.877	0.505	0.895
Korea			
$ln\frac{K^{ICT}}{Y}$	1.346*	-2.187	0.841
	(0.681)	(1.406)	(1.506)
$ln\frac{K}{Y}$	-1.867	5.546**	-3.679
	(1.676)	(2.404)	(3.240)
N	667	667	667
R^2	0.782	0.397	0.730
Netherlands			
$ln\frac{K^{ICT}}{Y}$	-1.539	0.180	1.359
	(1.254)	(2.593)	(1.391)
$ln\frac{K}{Y}$	2.076	1.973	-4.049
	(3.273)	(8.176)	(5.119)
N	621	621	621
R^2	0.695	0.277	0.777
Slovenia			
$ln\frac{K^{ICT}}{Y}$	0.321	-0.577	0.255
	(0.745)	(0.641)	(0.462)
$ln\frac{K}{Y}$	-0.579	-1.743	2.322
	(2.838)	(2.461)	(1.818)
N	253	253	253
R^2	0.461	0.232	0.401

Continued on next page

Table 3.6 – *continued from previous page*

Dependent Variable: Relative Compensation Share of the Respective Skill Group			
Variable	High-Skilled	Medium-Skilled	Low-Skilled
Sweden			
$ln\frac{K^{ICT}}{Y}$	-1.022	0.256	0.766
	(1.174)	(1.870)	(1.178)
$ln\frac{K}{Y}$	-1.750	4.577	-2.827
	(2.092)	(2.897)	(1.618)
N	299	299	299
R^2	0.668	0.375	0.901
UK			
$ln\frac{K^{ICT}}{Y}$	-0.994	2.454	-1.460
	(1.711)	(3.743)	(2.606)
$ln\frac{K}{Y}$	-0.550	1.014	-0.464
	(4.600)	(12.518)	(8.267)
N	828	828	828
R^2	0.774	0.638	0.908
USA			
$ln\frac{K^{ICT}}{Y}$	-0.431	-0.213	0.645
	(0.970)	(2.083)	(1.163)
$ln\frac{K}{Y}$	-1.584	1.600	-0.0166
	(2.755)	(5.630)	(3.041)
N	828	828	828
R^2	0.877	0.142	0.855

***,**,*: statistically significant at 1, 5, and 10 % level, respectively;
Fixed Effects estimation; Robust standard errors in parentheses;
Year dummies are included in each regression;
The regressions are weighted by average labor costs share of each industry.

3.4.2 Estimation Results by Industries

Intuitively the same industries across advanced countries use the same technology. Therefore, estimating a share equation for one industry across countries may lead to more consistent estimates than estimating a share equation for one country across industries. Another way to analyze the effect of ICT is to take each industry and pool over countries and thereby controlling for country specific effects through the fixed effects estimation within one industry. The results of estimating equation (3.5) by industry are listed in table 3.8.[8] The results by industry are also heterogeneous, but may be explainable by the differences in technology between the industries. An overview of the qualitative results is given in table 3.7.

The results can be sorted into three subgroups. The first group contains five industries,

[8]The results are estimated only with data from Australia, Austria, Denmark, Finland, Italy, Japan, Korea, Netherlands, UK, and USA. These are the countries with the longest available time series.

Textiles, Textile, Leather and Footwear; *Pulp, Paper, Printing and Publishing*; *Chemicals*; *Machinery, Nec.*; and *Post and Telecommunications*. In these industries ICT investments have a significant positive impact on high-skilled workers' compensation share, while medium and low-skilled workers' compensation shares remain unaffected.

The second group contains the industries *Mining and Quarrying*; *Food, Beverages and Tobacco*; *Rubber and plastics*; *Electrical and Optical Equipment*; *Transport Equipment*; and *Real Estate, Renting and Business Activities*. In these industries ICT investments lead to a polarization on the bottom end of the distribution by skill-groups while the high-skilled compensation share is not affected. The coefficients for share of ICT investments in the regression for the medium-skilled skilled workers' compensation share is negative and significant and it is positive and mostly significant at the 10 percent level for the low-skilled. Within these industries the gains of the low-skilled due to ICT investments seem to be at the expense of the medium-skilled, whose compensation shares are negatively affected by ICT investments.

The last group contains all remaining industries, including all service industries except *Post and Telecommunications*. In these industries ICT investment do not influence the relative compensation shares significantly in the relevant time frame.

Table 3.7: Overview of Results for the Industry Estimation.

Variable	High-Skilled	Medium-Skilled	Low-Skilled
positive significant on the 10% level	Textiles, Textile, Leather, Footw. Pulp, Paper, Printing, Publishing Chemicals Manufacturing Nec. Post and Telecommunications		Mining and Quarrying Food, Beverages and Tobacco Rubber and Plastics Electrical and Optical Equipment Transport Equipment*
insignificant	Mining and Quarrying Food, Beverages and Tobacco Wood and of Wood and Cork Coke, Refined Petroleum, Nuclear F. Rubber and Plastics Other Non-Metallic Mineral Basic Metals and Fabricated Metal Machinery, Nec. Electrical and Optical Equipment Transport Equipment Electricity, Gas and Water Supply Construction Wholesale and Retail Trade Hotels and Restaurants Transport and Storage Financial Intermediation Real Estate, Renting Other Services	Textiles, Textile, Leather, Footw. Wood and of Wood and Cork Pulp, Paper, Printing, Publishing Coke, Refined Petroleum, Nuclear F. Chemicals Other Non-Metallic Mineral Basic Metals and Fabricated Metal Machinery, Nec. Manufacturing Nec. Electricity, Gas and Water Supply Construction Wholesale and Retail Trade Hotels and Restaurants Transport and Storage Post and Telecommunications Financial Intermediation Other Services	Textiles, Textile, Leather, Footw. Wood and of Wood and Cork Pulp, Paper, Printing, Publishing Coke, Refined Petroleum, Nuclear F. Chemicals Other Non-Metallic Mineral Basic Metals and Fabricated Metal Machinery, Nec. Manufacturing Nec. Electricity, Gas and Water Supply Construction Wholesale and Retail Trade Hotels and Restaurants Transport and Storage Post and Telecommunications Financial Intermediation Real Estate, Renting Other Services
negative significant on the 10% level		Mining and Quarrying Food, Beverages and Tobacco Rubber and Plastics Electrical and Optical Equipment Transport Equipment Real Estate, Renting	

* Here results of estimation of equation (3.3) are given, as the constant returns to scale in production are rejected. See also subsection 3.4.4.

As mentioned above, it can be assumed that the same technology is used in the same industry in different countries. Differences in the findings for the effect of ICT investments across industries may be attributable to different tasks in the industry. A high-skilled worker in the sector for financial intermediation has most likely a different set of tasks than a high-skilled worker in chemicals. The same holds if one compares medium- or low-skilled workers in hotels compared to mining. Autor et al. (2003) introduce the idea that differences in the tasks determine whether a worker's wage and employment are positively or negatively influenced by ICT. In this task approach it is claimed that routine tasks are more easily substitutable with computers while interactive and non-routine tasks are more complementary to ICT. Autor et al. (2008), Goos and Manning (2007), and Spitz-Oener (2006) find evidence for these effects in the US, the UK, and in Germany and also discuss an ongoing polarization in the wage distribution due to the fact that ICT has only a marginal influence on manual tasks. Autor et al. (2006) take this idea and combine the tasks with skill. In a theoretical model they use the idea that high-skilled workers perform mainly abstract, meaning non-routine and interactive tasks, while medium and low-skilled workers have routine or manual tasks. Differences in the results for the estimation by industry could therefore be attributed to differences in tasks structures for the industries. Costinot et al. (2009) calculate the routine tasks content by industry for the US in 2006. I tried to match their industry classification to mine and see whether the routineness of the industry can explain in which industries high-, medium-, and low-skilled workers compensation shares are affected more intensively or less by ICT investments.[9] Unfortunately, Costinot et al. (2009) use a lower industry aggregation which is restricted to manufacturing. Thus, I was only able to match half of the industries to the ones used in this study. In three of the four routine industries ICT investments have a significantly negative effect on medium-skilled compensation share. In the non-routine industries high-skilled workers compensation shares increase due to ICT investments in all four, but only in two these on a one percent significant level. In order to further analyze these effects, it would be necessary to investigate what tasks each skill group in each industry has. This may explain the differences which are observable in this estimation. However this is beyond the scope of this paper and thus left to future research.

[9]For this exercise I divide the industries in Costinot et al. (2009) by their routineness into thirds. The third with highest level of routineness I call "routine", the next third "medium routine", and the last "non-routine". I then match the industries to the ones I use. This leads to the following classifications: non-routine: *Pulp, Paper, Printing and Publishing*; *Coke, refined petroleum and nuclear fuel*; *Electrical and Optical Equipment*; *Chemicals*; medium routine: *Mining and Quarrying*; *Wood and Cork*; *Basic Metals and Fabricated Metal*; *Machinery, Nec.*; routine: *Food, Beverages and Tobacco*; *Textiles, Textile, Leather and Footwear*; *Rubber and Plastics*; *Transport Equipment.*

Table 3.8: Regression by Industry

Dependent Variable: Relative Compensation Share of the Respective Skill Group			
Variable	High-Skilled	Medium-Skilled	Low-Skilled
Mining and Quarrying			
$ln\frac{K^{ICT}}{Y}$	-0.859	-0.794*	1.653**
	(0.737)	(0.402)	(0.672)
$ln\frac{K}{Y}$	2.726	5.171	-7.898
	(2.862)	(2.916)	(4.391)
N	304	304	304
R^2	0.753	0.700	0.837
Food, Beverages and Tobacco			
$ln\frac{K^{ICT}}{Y}$	0.370	-4.696**	4.326**
	(1.298)	(1.792)	(1.706)
$ln\frac{K}{Y}$	-1.815	2.970	-1.155
	(3.249)	(3.697)	(3.882)
N	309	309	309
R^2	0.714	0.752	0.824
Textiles, Textile, Leather and Footwear			
$ln\frac{K^{ICT}}{Y}$	3.240**	2.600	-5.840
	(1.197)	(3.027)	(3.755)
$ln\frac{K}{Y}$	2.667	3.015	-5.681
	(2.559)	(4.940)	(5.139)
N	304	304	304
R^2	0.737	0.655	0.758
Wood and of Wood and Cork			
$ln\frac{K^{ICT}}{Y}$	0.533	1.495	-2.028
	(0.916)	(1.458)	(2.330)
$ln\frac{K}{Y}$	0.451	-0.586	0.134
	(2.540)	(6.850)	(6.966)
N	308	308	308
R^2	0.718	0.759	0.811
Pulp, Paper, Printing and Publishing			
$ln\frac{K^{ICT}}{Y}$	2.000**	-2.691	0.691
	(0.874)	(2.516)	(2.396)
$ln\frac{K}{Y}$	-2.709	-3.689	6.398
	(3.142)	(5.477)	(5.699)
N	309	309	309
R^2	0.821	0.623	0.800
Coke, Refined Petroleum and Nuclear Fuel			
$ln\frac{K^{ICT}}{Y}$	0.278	-0.783	0.504
	(0.561)	(1.737)	(1.923)
$ln\frac{K}{Y}$	-1.792	1.397	0.395
	(1.067)	(3.544)	(3.983)
N	304	304	304
R^2	0.835	0.466	0.689

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Table 3.8 – *continued from previous page*

Dependent Variable: Relative Compensation Share of the Respective Skill Group			
Variable	High-Skilled	Medium-Skilled	Low-Skilled
Chemicals and Chemical			
$ln\frac{K^{ICT}}{Y}$	2.241***	-2.528	0.287
	(0.467)	(3.657)	(3.561)
$ln\frac{K}{Y}$	-2.376	4.497	-2.121
	(1.532)	(6.494)	(6.727)
N	309	309	309
R^2	0.896	0.360	0.699
Rubber and Plastics			
$ln\frac{K^{ICT}}{Y}$	0.052	-3.636**	3.584*
	(0.717)	(1.430)	(1.680)
$ln\frac{K}{Y}$	-3.568*	7.614	-4.046
	(1.919)	(4.386)	(4.310)
N	302	302	302
R^2	0.755	0.702	0.763
Other Non-Metallic Mineral			
$ln\frac{K^{ICT}}{Y}$	0.141	-0.732	0.591
	(0.991)	(1.435)	(2.211)
$ln\frac{K}{Y}$	0.006	10.49	-10.50
	(3.148)	(6.116)	(9.102)
N	308	308	308
R^2	0.688	0.778	0.792
Basic Metals and Fabricated Metal			
$ln\frac{K^{ICT}}{Y}$	0.284	0.177	-0.461
	(0.776)	(1.932)	(2.540)
$ln\frac{K}{Y}$	-3.272	0.280	2.992
	(2.912)	(6.964)	(9.385)
N	309	309	309
R^2	0.694	0.703	0.737
Machinery, Nec.			
$ln\frac{K^{ICT}}{Y}$	-0.465	-1.517	1.981
	(2.217)	(1.777)	(2.688)
$ln\frac{K}{Y}$	-3.712	1.470	2.242
	(3.765)	(4.348)	(7.204)
N	309	309	309
R^2	0.749	0.603	0.792
Electrical and Optical Equipment			
$ln\frac{K^{ICT}}{Y}$	1.260	-4.203**	2.943*
	(0.813)	(1.563)	(1.599)
$ln\frac{K}{Y}$	-8.574***	6.155	2.419
	(1.623)	(4.708)	(5.712)
N	309	309	309
R^2	0.909	0.542	0.812

Continued on next page

Table 3.8 – *continued from previous page*

Dependent Variable: Relative Compensation Share of the Respective Skill Group			
Variable	High-Skilled	Medium-Skilled	Low-Skilled
Transport Equipment			
$ln\frac{K^{ICT}}{Y}$	1.469	-3.812**	2.343
	(0.811)	(1.437)	(1.661)
$ln\frac{K}{Y}$	-1.454	0.377	1.077
	(3.335)	(4.657)	(7.281)
N	309	309	309
R^2	0.700	0.667	0.789
Manufacturing Nec.; Recycling			
$ln\frac{K^{ICT}}{Y}$	2.060*	0.261	-2.320
	(1.051)	(1.396)	(2.390)
$ln\frac{K}{Y}$	-3.192	9.665	-6.473
	(3.160)	(5.464)	(7.994)
N	306	306	306
R^2	0.592	0.718	0.740
Electricity, Gas and Water Supply			
$ln\frac{K^{ICT}}{Y}$	0.753	-1.386	0.634
	(1.178)	(1.041)	(1.175)
$ln\frac{K}{Y}$	-4.610	-6.952*	11.560
	(7.642)	(3.493)	(9.544)
N	309	309	309
R^2	0.741	0.487	0.733
Construction			
$ln\frac{K^{ICT}}{Y}$	-0.118	0.930	-0.812
	(0.734)	(1.564)	(1.530)
$ln\frac{K}{Y}$	-1.912	6.006	-4.095
	(3.242)	(4.621)	(4.676)
N	307	307	307
R^2	0.589	0.699	0.836
Wholesale and Retail Trade			
$ln\frac{K^{ICT}}{Y}$	0.0414	-1.930	1.888
	(1.038)	(1.423)	(1.267)
$ln\frac{K}{Y}$	-4.547	12.62	-8.074
	(5.151)	(11.17)	(12.97)
N	309	309	309
R^2	0.641	0.464	0.671
Hotels and Restaurants			
$ln\frac{K^{ICT}}{Y}$	0.703	-0.855	0.152
	(0.796)	(1.552)	(2.070)
$ln\frac{K}{Y}$	8.071	2.402	-10.47
	(6.479)	(8.217)	(9.186)
N	307	307	307
R^2	0.585	0.665	0.725

Continued on next page

Table 3.8 – *continued from previous page*

Dependent Variable: Relative Compensation Share of the Respective Skill Group			
Variable	High-Skilled	Medium-Skilled	Low-Skilled
Transport and Storage			
$ln\frac{K^{ICT}}{Y}$	1.006	0.096	-1.102
	(0.702)	(2.212)	(2.596)
$ln\frac{K}{Y}$	-0.021	2.348	-2.326
	(4.755)	(8.091)	(8.525)
N	309	309	309
R^2	0.625	0.700	0.777
Post and Telecommunications			
$ln\frac{K^{ICT}}{Y}$	2.208*	-3.160	0.953
	(1.115)	(2.506)	(2.275)
$ln\frac{K}{Y}$	-7.344**	-3.382	10.73
	(2.838)	(7.666)	(9.523)
N	309	309	309
R^2	0.810	0.369	0.678
Financial Intermediation			
$ln\frac{K^{ICT}}{Y}$	-0.192	-1.094	1.286
	(1.486)	(1.101)	(1.330)
$ln\frac{K}{Y}$	1.369	-4.387	3.018
	(4.047)	(2.731)	(3.471)
N	309	309	309
R^2	0.804	0.698	0.638
Real Estate, Renting and Business Activities			
$ln\frac{K^{ICT}}{Y}$	-0.177	-1.262*	1.439
	(0.982)	(0.616)	(0.978)
$ln\frac{K}{Y}$	1.539	8.512**	-10.050*
	(3.779)	(3.714)	(5.051)
N	309	309	309
R^2	0.761	0.392	0.771
Other Community, Social and Personal Services			
$ln\frac{K^{ICT}}{Y}$	-0.042	-0.211	0.253
	(1.212)	(1.402)	(2.221)
$ln\frac{K}{Y}$	-8.689**	6.906	1.782
	(2.792)	(5.700)	(7.326)
N	309	309	309
R^2	0.620	0.467	0.657

***,**,*: statistically significant at 1, 5, and 10 % level, respectively;
Fixed Effects estimation; Robust standard errors in parentheses;
Year dummies are included in each regression;
The regressions are weighted by average labor costs share of each industry.
Countries: Australia, Austria, Denmark, Finland, Italy, Japan, Korea, Netherlands, UK, and USA.

3.4.3 Estimation Results under the Assumption of a Structural Break

The aforementioned results are surprising, especially for the estimation for individual countries, as other studies find a significant and positive effect of ICT on the high-skilled wage shares. For example O'Mahony et al. (2008) find strong positive effects for the UK and the US. Nevertheless, they also test for structural breaks due to a de-skilling in the long run. They find structural breaks between 1991 and 1994 for high- and medium-skilled workers compensation shares. According to Jorgenson (2001) the price for computer technology decreased in the mid 1990s such that in 1995 the investments into ICT accelerated in production. Thus I re-estimated all regressions with dummies for a structural break for the time period before 1994 and after.[10] I do this only for Australia, Austria, Denmark, Finland, Italy, Japan, Korea, Netherlands, UK, and USA, as these times series are long enough prior to 1994. These results can be found by country in table 15 and by industry in table 16. The coefficients for ICT investment share and the capital output ratio were tested for a structural break. Where a structural break can be assumed on the 10 percent level the coefficient values are given in italics.

Estimation Results by Country

For the high-skilled workers the impact of ICT on their wage share has changed over time in Australia, Denmark, Finland, and the US. In Denmark and the US the impact of ICT on the high-skilled compensation share was insignificant before 1995 and then turned positive and significant for the time period between 1995 and 2005. In Australia the coefficient was highly significant in the earlier period and then turned insignificant later on. In Finland the negative sign of the coefficient only holds for the earlier period, which seems to drive the results of the result for the estimation where no structural break is assumed. In Japan the positive and significant impact of ICT on the high-skilled compensation share was positive already until 1994 and became even larger and more significant thereafter. In six out of the 10 countries analyzed here, the coefficient of ICT investments is significantly different in the later period compared to the time before 1995.

While the results for the high-skilled compensation shares are quite heterogeneous the results on the medium-skilled compensation shares are quite consistent across countries. Except for the UK, ICT investments have a negative impact on the medium-skilled

[10] For robustness I also estimated everything assuming a break between 1990 and 1991. The results are not much different, only some single coefficients are more or less significant with the earlier break. The differences between the coefficients is only a fraction of a standard deviation in most cases and is especially low for the high-skilled shares.

workers' shares since 1995. Only in Finland a significant positive impact of ICT turned to negative but insignificant. As for the high-skilled compensation share estimation there is a significant difference for most coefficients between the two time periods.

Concerning the low-skilled compensation share the negative significant impacts found above can again be found for Australia and Finland, although only for the time until 1994. Afterwards it is insignificant. For the other countries, ICT influences the low-skilled workers' compensation shares positively, especially in the second period. Only in the UK ICT does not seem to have an impact at all on the relative compensation. As it can be seen from the results, in most cases the sign of the coefficients do not change over time, only the level of significance changed. Especially in the US there is a substantial difference between the two time periods with respect to the influence of ICT on the relative compensation shares.

Estimation Results by Industry

The positive results for the influence of ICT investments on the high-skilled workers' compensation shares are found for the whole time period for *Textiles, Textile, Leather and Footwear*; *Pulp, Paper, Printing and Publishing*; *Chemicals*; *Manufacturing, Nec.; Recycling*; *Transport and Storage*; and *Post and Telecommunications* and is mostly found for the time period until 1994. For the more recent time period the coefficients turn insignificant or even significantly negative in the case of *Transport and Storage*. In *Construction*; *Transport Equipment*; and *Machinery, Nec.* ICT investments also had a significantly negative impact on the high-skilled workers' compensation shares. While for a half of the industries the coefficient for ICT is positive for the time between 1995 and 2005 it is only significant in *Chemicals*.

While the results across countries showed a strong negative impact of ICT on the medium-skilled compensation shares in the second time period, the impact is much less pronounced in the regressions across industries. Only in *Manufacturing, Nec.; Recycling* this can be found. In *Food, Beverages and Tobacco*; *Rubber and Plastics*; and *Transport Equipment* the significant negative impact of ICT turned insignificant after 1995. In *Machinery, Nec.*; *Electrical and Optical Equipment*; *Electricity, Gas and Water Supply*; *Wholesale and Retail Trade*; and *Real Estate* the earlier negative influence of ICT on medium-skilled workers' compensation shares turned from negative to positive.

For low-skilled workers' compensation shares, ICT has only a significantly negative impact in the time from 1995 in *Electricity, Gas and Water Supply*. A positive and significant influence of ICT on this share is found for the earlier period in *Food, Beverages and Tobacco*; *Rubber and plastics*; *Machinery, Nec.*; and *Electrical and Optical Equip-*

ment and in *Mining and Quarrying*; *Transport Equipment*; and *Transport and Storage* for the period after 1995.

For the industry estimation only very few estimations show a significant difference in the ICT coefficients between the two periods although there are clear changes in signs and significance levels as mentioned above. In the regressions I also allow the intercept to change between 1994 and 1995. The difference in the intercept was only significant in 8 cases for the high-skilled compensation share. For the medium and low-skilled compensation share estimation the difference in the intercept was significant on a 10 percent level for 14 and 16 industries.

O'Mahony et al. (2008) also find a weakening of the impact of ICT on the relative compensation shares over time. They describe the skill-bias of technical change as a temporary phenomenon for the cases of the UK and the USA. These results, with or without structural break, show that ICT investments are not likely to be the sole source of the continuously increasing high-skilled compensation shares.

3.4.4 Robustness Checks

Dropping the Constant Returns to Scale Assumption

As mentioned before, I estimated the regressions for equation (3.3) which does not assume constant returns to scale in the production function, as a robustness check.[11] Generally the results for the coefficient on ICT investments does not differ in the sign or significance from the coefficients on the share of ICT investments in value added from equation (3.5). On the country level there are only differences for Italy and the US. In both countries the coefficient in the low-skill share equation differs, as it is positive and significant if constant returns to scale are not assumed, while it is positive, but insignificant under the restriction. As for these two cases the constant returns restrictions had to be rejected (see table 13). I therefore included the significance of the coefficient on ICT investments into the result-table above, table 3.5. The same holds for the industry *Transport Equipment*, where in the unrestricted estimation the ICT investments coefficient is also significantly positive while the assumption of constant returns to scale had to be rejected.

[11] Considering the amount of tables in the paper, I leave the result tables of the robustness checks out of the paper. Nevertheless, they are available on request.

ICT Fixed Capital Stock

The EU KLEMS data on capital includes data on ICT capital stocks. Comparing ICT fixed capital stocks and ICT investments shows a correlation of 0.88. As a robustness check I estimate the share equation where I use the log ICT-capital-stock-output ratio and the log Non-ICT-capital-stock-output ratio as regressors. The results are very close to the ones described above for both regressors. While there are shifts in the level of significance, the coefficients mostly have the same sign in the estimations. In Finland, Italy, Slovenia, and Sweden all coefficients for the ICT-capital-stock turn insignificant. In Germany, Japan, and Korea the coefficient in the medium-skilled share equation is negative and turns significant and in the low-skilled estimation they are positive and significant. In Japan and Korea the coefficient in the high-skilled estimation is positive and significant as well. The results for the US change to a negative significant impact of ICT-capital on the high-skilled relative compensation share and a positive on the medium-skilled share. The results for Australia again mirror the hypotheses of skill-biased technological change, while Japan and Korea mirror rather the hypotheses of the task-literature and, together with Germany, a polarization at the bottom of the skill distribution. Using stocks rather than investments into ICT in the industry estimation, leaves hardly any significant results. Only two coefficients on ICT remain significant, while the signs of the coefficients are almost always the same as above. The lower precision of the estimation could be due to higher measurement error in the ICT stock variable as it contains assumptions on the depreciation of the ICT.

3.5 Conclusion

In this paper I analyze the impact of ICT investments on relative compensation shares of high-, medium-, and low-skilled workers in 23 private industries of 14 industrialized countries. The analysis therefore includes a much larger number of countries than earlier studies and also covers most of the private sector opposed to studies that focus on manufacturing only. Additionally, ICT investments are directly included in the analysis. This enables an assessment of the pervasiveness of the skill-biased characteristics ICT across countries and over time. Although ICT investments influence the relative compensation by skill, I conclude that there is no persistent impact of ICT investments on the relative wage shares across developed countries. Only for Austria, Denmark, and Korea, I find ICT investments to be skill-biased for high-skilled workers. A polarizing impact on the lower end of the skill-distribution can be found in Austria, Germany, Italy, and the US.

Nevertheless, there seem to be stronger impacts of ICT investments in individual industries. I argue that the impact of technological changes should be measured on the industry level as opposed to the country level. The reason is that within industries the production should be more similar than the production process across industries within one country. On the industry level there is evidence that observed polarization in many countries may be driven by the different task structures in the industries. In a subset of five industries, high-skilled workers' compensation shares increase due to investments into ICT. In a different set of six industries, ICT seems to polarize wages and employment at the bottom end of the skill distribution. Here, ICT investments decrease the medium-skilled workers' relative compensation shares and/or increase the lower-skilled workers' shares. These mixed results may be explained by differences in tasks across industries for the skill groups. Notably, in service industries the workers relative compensation shares are much less affected by ICT investments, except for Post and Telecommunications where the entire industry changed dramatically through innovations in ICT.

Furthermore allowing for a structural break in the early to mid 1990s shows that the impact of ICT on relative skill-demands has changed over the last 35 years. Before the mid 1990s, ICT had a positive impact on the relative wage-shares of high-skilled workers in a substantial number of industries, which has changed to insignificance after the mid 1990s. Lower skilled workers' compensation shares seem less influenced by ICT investments although there tends to be a negative influence on the medium-skilled workers wage shares and a positive on the low-skilled workers shares. This suggests that firms and workers have adapted to the new technology and that the linear impact suggested by the hypothesis of skill-biased technological change was not persistent over time. After the mid 1990s, technology seems to lead more to a polarization at the lower end of the income distribution as medium-skilled workers' compensation shares tend to be affected more negatively by ICT while low-skilled workers now gain in their wage shares.

In order to understand more clearly how the industries differ in their relative labor demand due to ICT, an investigation of the task structure by industry would lead to interesting future research. As there are changes of the impact of ICT across time, there is also the question whether the demand for skill changed or if the workers' skills adjusted. This would be a question for future research which could be addressed with an analysis on the micro level.

This study shows that ICT investments influence the relative compensation shares, but they are not the sole force for the continuing divergence in the relative compensation shares especially on the upper end of the income distribution. High-skilled workers' compensation shares are still growing relative to medium- and low-skilled workers in many developed countries. Further analysis which includes other candidate explanations, such as increasing globalization or changes in institutions, may shed more light on the determinants of the changes in the relative income distribution.

4 Bargaining, Openness, and the Labor Share

Abstract. This paper investigates determinants of changes of the labor share in developed countries with a focus on Western Europe. Using a country-industry panel that covers the private sector, the paper focuses on long and short-run changes within industries. The results show a large and time-persistent impact of increasing globalization on the labor share, especially if the within-industry changes are considered. Openness seems to be the driving force for downward movements in the industry level labor shares while technological and institutional forces impact these shares positively. Furthermore, while investments into information and communication technology (ICT) increase productivity of workers, it has a negative impact on the labor share as it enables higher economic integration which lowers the labor share. Economic integration has stronger impact on the polarization in Western European labor markets than ICT.

4.1 Introduction

Since the 1980s Western European countries have been confronted with rising inequality, falling real wages for subgroups of workers and high unemployment while economies were growing at the same time. These developments lead to the question on how income is distributed among factors of production. The share of total income from production received by the workers, the labor share, captures the labor market outcome of workers. It is influenced by bargaining power, globalization, and technological progress. Especially, increasing economic integration and advances in information and communication technologies (ICT) have changed the production processes and possibilities for firms and thus affected the functional distribution of income. In order to address the issue of a growing capital share or growing inequality, it is crucial to understand the main influences determining the division of income.

In this paper, I investigate these influences in a unifying framework. I estimate the short and long-run dynamics of labor market institutions, technology, and economic integration on the labor share in Western Europe on the industry level. Employing a

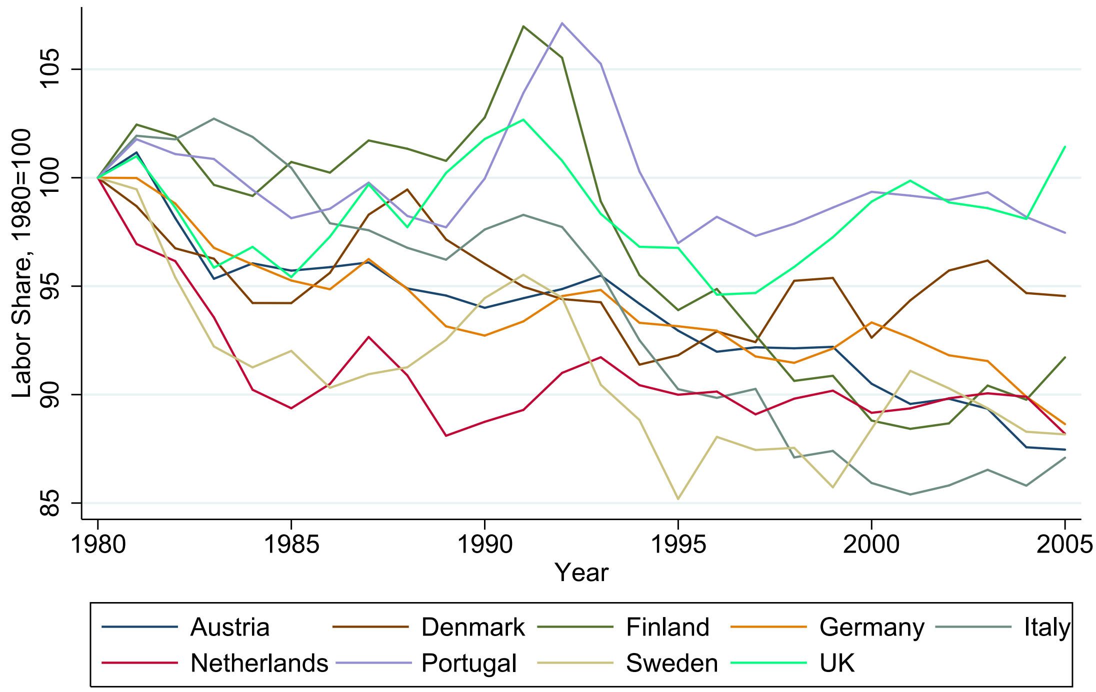

Figure 4.1: Labor Share Relative to its Value in 1980; source: EU KLEMS, Author's Calculations.

large dataset from various sources for nine Western European countries on a two-digit industry level, I estimate the within-industry changes of the labor share which are due to various influences on the bargaining process in the labor market. Investigating the short and long-run dynamics is especially interesting as most Western European countries where faced with a negative trend in the labor share since 1980 while the labor share also moved with the business cycle. Figure 4.1 shows the evolution of the labor share by country for the large dataset from 1980 to 2005 where the value in 1980 is set to 100. The trends are different in their magnitude and timing. Simply judging by the graphs, the labor share seems to have larger swings in Finland, Denmark, Portugal, and the UK while in the other countries the labor shares seem to swing less but with a stronger trend. This analysis aims at finding common sources for the short- and medium-run movements of the shares within industries and countries.

I conclude that next to capital, which is a complement to labor in production, international trade and increasing economic integration have long-term impacts on the overall labor share. While these influences are similar across sectors and skill-groups, the influences of labor market institutions depend on the skill-level and sector. Furthermore, I investigate the connection between ICT-capital and economic integration. I find that ICT-capital itself is complementary to labor, especially in the service sector and for medium-skilled workers. The overall impact of ICT-capital on the labor share is nevertheless insignificant as it enables higher economic integration also through cheaper production and investments abroad.

After Blanchard (1997) highlighted the increasing capital share in European countries, a literature trying to understand the decreasing labor share evolved. The influential paper by Bentolia and Saint-Paul (2003) describes the direct relationship between the capital-output ratio and the labor share. They find a close relationship between both and are able to determine the impact of institutions on this relationship. They also estimate a model based on industry-level data and find support for a strong relationship between the technological influences and less influence of institutions on the labor share. Unfortunately, they do not include information on globalization or ICT. The same holds for Checchi and Garcia-Penalosa (2010), who find a higher importance of institutions on the labor share, but only estimate on the country level. Other studies, such as Harrison (2002), Guscina (2007), Jaumotte and Tytell (2008), the European Commission (2007), and Jayadev (2007) investigate the impact of different openness indicators on the labor share and find negative influences of increasing economic integration on the labor share. The European Commission (2007) also include the investigation of several skill groups and find heterogeneous results by skill for most variables. These papers are based on country level data and therefore cannot differentiate between variation coming from the sectoral composition within an economy or changes in the labor market outcomes within industries. If most variation in developed countries is coming from a growing share of value added of industries with lower labor share, such as of service industries, then it is desirable to estimate on industry-level rather then on country-level.

Using an error-correction approach, I can distinguish between long-term impacts and short-run dynamics. Furthermore, I am able to look into more detail on how manufacturing and service sector are affected differently. Having information about the labor share of high-, medium-, and low-skilled workers it is possible to analyze whether technology, institutions, or globalization is favoring specific skill-groups and whether these influences increase inequality not only between capital and labor but also within labor categories. As ICT and globalization influence each other, I also investigate the specific individual effects as well as a common impact of ICT and globalization on the labor share.

In the remainder of the paper I will first derive hypothesis on the determinants of the labor share from a theoretical bargaining model. This section also includes the econometric specification. In the third part of the paper I will explain the data and present some descriptive statistics. The empirical results and a discussion can be found in section four. Section five concludes.

4.2 Theoretical Considerations and the Estimation Procedure

4.2.1 Determination of the Labor Share in a Nash-Bargaining Framework

In order to analyze the labor share, the wage and employment setting mechanisms have to be analyzed. Under perfect competition in the labor and product markets the labor market will clear under profit maximization of firms if the firms choose employment such that the marginal product of labor equals the real wage. Thus, the demand for labor is defined by its marginal productivity. In a well cited paper Bentolia and Saint-Paul (2003) show that under the two assumptions of constant returns to scale and labor-augmenting technological progress the labor share is a direct function of the capital-output ratio as long as wages equal the marginal product of labor. The relationship between the labor share and the capital output ratio, which they call "SK schedule", depends on the production technology and, most importantly, on the elasticity of substitution between capital and labor. Complementarity of the two input factors lets the labor share rise if the capital-output ratio increases, while substitutability results in a decrease of the share. Under these assumption of perfect competition, the sole determinant of the labor share is the production technology.

Bentolia and Saint-Paul (2003) discuss factors which cause movements *on* the SK-schedule (e.g. input-price movements), movements *of* the SK-schedule (e.g. shifts in technology), and movements which lead to outcomes which are not on the schedule at all. For the outcome to lie *off* the SK-schedule, there needs to be a divergence of the wages away from the marginal product of labor. This can be the case if workers have bargaining power and manage to negotiate a wage which lies above the labor demand curve at a given level of employment.

Classically, the bargaining of workers and firms over their quasi-rents is represented by a Nash-Bargaining framework. Usually, the literature differentiates between two ways of bargaining.[1] In the right-to-manage model, the firms and workers bargain over wages and the firm then sets the level of employment independently such that it maximizes its profits. The wage-employment combination therefore lies on the labor demand curve of the firm. In the efficient bargaining model the workers and firms bargain over wages

[1]See McDonald and Solow (1981), Lever and van Veen (1991), and Cahuc and Zylberberg (2004) for an in depth discussion of both approaches.

and employment simultaneously. The resulting possible wage-employment combinations define a contract curve which lies to the right of the labor demand curve in the wage-employment plane and is upwards sloping. Thus, for every wage the firms employ more workers than they would if the workers did not have any bargaining power.

Nash-Bargaining is a common starting point in the literature when the labor share is analyzed. Various versions of the bargaining processes described above can be found.[2] In the following, I derive the labor share from a simple efficient bargaining model with outside options of the firms and workers and a production technology employing capital and labor. I will also discuss the effects of changes in competition in the product markets and irreversible capital investments on the labor share.

In this model workers and firms bargain over wages and employment by maximizing their quasi-rents. The quasi-rent of the workers is defined by the difference between the wage bill, denoted by product of wages, w, and employment, L, and the income under the workers' outside option, $L\overline{w} \geq 0$. As workers are not fully mobile, the outside option is usually regarded as unemployment benefits rather than alternative wages outside the economy. The quasi-rent of the firm is then the total revenue of the firm, $PY = PF(K, L)$ minus the costs of the input factors labor and capital, wL and rK, and minus its outside option, $D \geq 0$. D could be the net profits of a possible relocation of the production process abroad. Workers and firms maximize the product of their quasi-rents, weighted by their respective bargaining power, α and $(1 - \alpha)$, with respect to wages and employment:

$$max_{w,L} \left(L\left(w - \overline{w}\right)\right)^{\alpha} \left(PF\left(K, L\right) - wL - rK - D\right)^{1-\alpha} \tag{4.1}$$

The first-order conditions are as follows

$$w: \ \alpha \left(PF\left(K, L\right) - wL - rK - D\right) = \left(1 - \alpha\right)\left(w - \overline{w}\right) L \tag{4.2}$$

$$L: \ \alpha \left(PF\left(K, L\right) - wL - rK - D\right) = \left(1 - \alpha\right)\left(w - F_L\right) L \tag{4.3}$$

where F_L is the first derivative of $F\left(K, L\right)$ with respect to L.

[2] Bentolia and Saint-Paul (2003) explain both bargaining concepts, but do not introduce an outside option of the firm. Arpaia et al. (2009) derives the labor share under the assumption that low-skilled workers' wages and employment are bargained over while high-skilled are paid by their marginal product. Checchi and Garcia-Penalosa (2010) use a similar approach, where low-skilled workers bargain under a right-to-manage framework, while high-skilled workers are paid under an efficiency wage concept. Also the European Commission (2007) derive the labor share under the assumption of a right-to-manage framework. Jayadev (2007) introduces an outside option of the firm, while he leaves out capital in the production process.

From the two first-order conditions one can find, that under efficient bargaining, the bargained wages and employment are set in such a way that the marginal product of labor equals the outside option of the workers, $\frac{\overline{w}}{P} = F_L$.[3]

After rearranging equation (4.2) the following condition can be found

$$wL = \alpha\left(PF\left(K, L\right) - rK - D\right) + \left(1 - \alpha\right)\overline{w}L. \tag{4.4}$$

Dividing this by total revenue, the labor share is then[4]

$$s_L = \alpha\left(1 - r\frac{K}{PY} - \frac{D}{PY}\right) + \left(1 - \alpha\right)\frac{\overline{w}L}{PY}. \tag{4.5}$$

Here, the labor share equals the sum of the shares of the quasi-rents of the firms and the labor-output ratio times the outside option of the workers, weighted by the respective bargaining power. The labor-output ratio times the outside option would equal the labor share if the wage of the workers would be exactly equal to their outside option.

Similarly, one can rearrange equation (4.3). This leads to the following labor share

$$s_L = \alpha\left(1 - r\frac{K}{PY} - \frac{D}{PY}\right) + \left(1 - \alpha\right)\frac{F_L L}{Y}. \tag{4.6}$$

This is the weighted sum of the share of the quasi-rent of the firm and the production elasticity of labor. This elasticity is equal to the labor share if the wage equals the workers' marginal productivity. If the workers have no bargaining power the share of quasi-rents from the firm disappears and only the partial production elasticity remains.

Combining equations (4.5) and (4.6) with the condition that $\frac{\overline{w}}{P} = F_L$ the labor share is a function G of the following variables:

$$s_L = G\left(F\left(K, L\right), D, \overline{w}, \alpha\right) \tag{4.7}$$

A rise in the bargaining power of the worker leads to a rise in the labor share, as it will secure a larger share of the rents if the quasi-rent of the firm is positive: $\frac{\partial s_L}{\partial \alpha} = 1 - \frac{rK}{PY} - \frac{D}{PY} - \frac{\overline{w}L}{PY}$. This is positive as long as total revenue exceeds the costs for capital, labor costs under the outside option of the worker, and the value of the outside option of the firm: $PY > rK + \overline{w}L + D$.

A rise in the outside option of the worker also leads to rise in the labor share, as long as employment is not reduced overproportionately as it is changed in order to adjust the

[3] This is a robust finding in other efficient bargaining models as well (Bentolia and Saint-Paul, 2003, p.14).

[4] This approach is similar to the derivation of the labor share by Jayadev (2007).

marginal productivity of labor. If the outside option of the firm improves, the quasi-rent of the firm shrinks and the labor share should decrease. A change in the production technology or other input factors have unclear effects on the share as it depends on the specification of the production technology, most importantly on the marginal rate of substitution between the input factors.

Changes in openness of the economy have diverse effects on the labor share. Openness will affect the outside option of the firm and the level of competition on the product market. Increasing openness will most likely generate production opportunities under which firms will be able to offshore production processes or import intermediate inputs from abroad more easily. These opportunities signify an increase in the firms' outside option and will thus reduce the labor share ($\frac{\partial s_L}{\partial D} = -\alpha \frac{1}{PY} \leq 0$).

Furthermore, openness can lead to a change in the competition firms face in the product markets. Changes in product market competition can have manifold consequences on labor market outcomes. If competition in the product market in a closed economy is not perfect, the price P is not exogenous and constant, but a function of $F(K, L)$ and determined by product demand. Under these considerations equation (4.1) changes to

$$max_{w,L} \left(L\left(w - \overline{w}\right)\right)^{\alpha} \left(P\left(F\left(K, L\right)\right) F\left(K, L\right) - wL - rK - D\right)^{1-\alpha} \tag{4.8}$$

Under imperfect competition, the labor share from equation (4.6) the becomes:

$$s_L^{IC} = \alpha \left(1 - r\frac{K}{PY} - \frac{D}{PY}\right) + (1-\alpha)\frac{F_L L}{Y}\left(1 - \frac{1}{|\eta_{Y,P}|}\right). \tag{4.9}$$

$\eta_{Y,P}$ is the product demand elasticity. As demand functions are usually negatively sloped, $\eta_{Y,P} < 0$ should hold. Under perfect competition every competitor faces a constant and fully elastic demand as the individual supply of the good is not able to change its price ($|\eta_{Y,P}| \to \infty$). The more inelastic the product demand function is, the higher is the price change due to a change in output. In this respect $|\eta_{Y,P}| \to 0$ can be associated with higher competition. From equation (4.9) it can be seen that less competition is associated with a lower labor share: $\frac{\partial s_L^{IC}}{\partial |\eta_{Y,P}|} > 0$ and $s_L \geq s_L^{IC}$.[5] Azmat et al. (2011) also find empirical indications that the labor share should increase if

[5] Arpaia et al. (2009), the European Commission (2007) and Bentolia and Saint-Paul (2003) discuss the influence of markups from the product market on the wage share in a closed economy. Only Arpaia et al. (2009) combine the markup and the bargaining decision although it is not clear how the markup is derived in the initial bargaining problem. Nevertheless they all also find a smaller wage share under less competition. Bentolia and Saint-Paul (2003) discuss how a markup affects the SK-schedule and finds that a markup puts the economy off the initial schedule if the markup moves over the business cycle. In the case of increasing economic integration the markup should shift more permanently to a higher or lower level.

competition increases. Generally it is not clear in which direction opening markets will affect the labor share. It could be assumed that competition rises as barriers to trade are decreased. Yet, firms are also confronted with a larger number of customers. For individual firms or industries relative competition might decrease. Furthermore openness can induce selectivity as only the most productive or innovative firms survive and thus competition decreases eventually.

If there is a net demand increase for products from this economy after markets open, there might not only be a shift in the markup, but demand may shift outwards such that prices and output should rise at the same time. The easiest case would be to analyze a shift from perfect competition in the closed market to a shift to perfect competition in the goods market while the input markets and thus their prices remain the same. As $\frac{\partial s_L}{\partial P} > 0$ the labor share would decrease if the international price level is below the prior domestic one in the closed market.[6] In order to analyze the case where total revenue changes and input prices remain constant, it is possible to redefine equation (4.5) as: $s_L = \alpha \frac{\pi}{pY} + (1-\alpha) \frac{\overline{w}L}{pY}$, where π, quasi-rent of the firm, is the firm's revenue minus non-labor input factors and its outside option. If π and L remain constant the labor share will decrease if total revenue increases. As the level of employment will most likely rise if output increases, the impact on the labor share and on π is again not clear anymore. If revenue increases more than capital used in production costs then π will increase. From these countervailing effects it is unclear it the labor share will increase or decrease under a net product market demand increase due to increasing openness. How production will react to this depends on the production function and input prices. Therefore it is unclear how changes in the size of the pie will affect the division of it.

So far, the bargaining process is treated as if everything is determined simultaneously. For this analysis it will make a differences what time horizon is considered. It is imaginable that investments into capital are already sunk when firms and workers bargain. In this case the quasi-rent of the firm, π, is reduced to revenue minus the outside option. This quasi-rent is clearly larger and the worker will be able to secure a larger part of total revenue. In the derivation of the labor share above, it is assumed that there are profits in the market, as revenue minus the costs of inputs has to be at least zero in order to not make any deficits. In the very short run, if costs for capital are sunk, workers may secure higher rents from the bargaining such that profits may be smaller than zero. Grout (1984) shows that the possibility of renegotiation of wages after capital investments are sunk may cause a disincentive to investment similar to a hold-up problem. How this underinvestment impact employment is discussed by Cahuc and Zylberberg

[6] If the product demand elasticity is constant, $\frac{\partial s_L}{\partial P} = \alpha \left(\frac{rK}{p^2 F} + \frac{D}{p^2 F} \right)$.

(2004, p.414). If capital and labor are substitutes, underinvestment in capital will lead to increasing usage of labor in production while the opposite is true if both factors are complements. The case of sunk capital investments is also part of the model of Bental and Demougin (2010). Similar to the model by Grout (1984), Bental and Demougin (2010) discuss the impact of shifts of the bargaining power on the incentives to invest. When the workers have lower bargaining power the hold-up problem becomes less severe. Bentolia and Saint-Paul (2003) argue that, in the short-run, bargaining leads to a higher labor share through higher wages at constant employment, while the firms are able to adjust their capital stock in the long run and change employment accordingly. Clearly the workers cannot uphold rents that exceed profits longer than the very short run. Firms would shut down or will try to adjust the production technology to a less labor-intensive technology. Acemoglu (2002a) explains how a wage push raises incentives for firms to invest into capital-biased technology in order to reduce labor demand in the long-run. Higher wages in the short-run may therefore lead to a lower labor share in the long-run.

4.2.2 Estimation Procedure

In the empirical part of the paper I investigate, in which way technology, institutions, and globalization have influenced the labor share in the short and longer run between 1980 and 2005. As discussed above, the determinants of the bargaining process can have different short- and long-run consequences on the labor share.

I estimate the long-run and short-run dynamics of these variables by an error-correction framework. This estimation technique allows for a long-run equilibrium between the dependent and independent variables and for an adjustment to this equilibrium after short-run deviations from it.[7] A derivation of this specification and variations of it can be found in Banerjee et al. (1993). Specifically, I estimate the following estimation

[7] See 4 for a discussion of cointegration between the variables of this study.

equation[8]:

$$\Delta\ s_{L,\,ijt} = \alpha s_{L,\,ij,t-1} + \beta X_{ij,t-1} + \sum_{s=0}^{q} \gamma_s \Delta X_{ij,t-s} + \mu_{ij} + \epsilon_{ijt} \tag{4.11}$$

The dependent variable is the first difference of the labor share in country i and industry j at time t. The regressors are the lagged levels of the labor share, $s_{L,\,ij,t-1}$, the lagged levels of the independent variables $X_{ij,t-1}$, and lagged differences of the independent variables $\Delta X_{ij,t-s}$. The parameter on the lagged levels of the labor share, α, is the error-correction parameter, which indicates whether there are long-run relationships and how quickly the system returns to this after a shock. The parameters on the levels of the independent variables specify this long-run relationship between the labor share and the respective variable. The vector γ_s describes the short-run dynamic of an independent variable on the labor share. μ_{ij} is the industry-country specific effect and ϵ_{ijt} is the error term.

The regressors in X are chosen according to equation (4.7). Technology, $F(K, L)$ is represented by the capital-output ratio. In order to account for technological change and newer technologies, which may have a different level of substitutability with labor, the ICT-capital-output ratio is included as well. The outside-option of the worker, $\overline{w}$, is represented by unemployment benefits. Bargaining power is included by union coverage. As the unemployment rate influences the bargaining power of the workers and their outside option, it is also included. The outside option of the firm is represented by two kinds of openness indicators: trade flows and trade restrictions. A detailed description of the data is given in the next section.

4.3 The Data

The data used in this analysis is taken from different sources. The basic source is the EU KLEMS dataset in its version of March 2008.[9] This is a harmonized sectoral dataset from

[8]This error-correction specification is equivalent to the dynamic fixed effects specification of Blackburne III and Frank (2007):

$$\Delta\ y_{ijt} = \phi\left(y_{ij,t-1} - \theta' X_{ij,t-1}\right) + \sum_{s=0}^{q-1} \gamma_s \Delta X_{ij,t-s} + \mu_{ij} + \epsilon_{ijt} \tag{4.10}$$

The error-correction term, which mirrors the speed of adjustment from short run shocks to the long-run equilibrium, ϕ, is equal to α, the parameter on the lagged level of the dependent variable, in equation (4.11). The same long-run equilibrium parameters can be found if the parameter in θ are divided by ϕ. The parameters on the ΔX are identical in both methods.

[9]Detailed information on the dataset can be found on the web page www.euklems.net or in Timmer et al. (2007a).

which the data on wages, employment, value added, capital measures, and deflators are taken. It covers the countries of the European Union and other advanced countries such as the US, Japan, or Australia, with comparable data across sectors, variable definitions and time. It was designed originally to measure economic growth and productivity. Thus, it includes many measures of different capital inputs as well as labor inputs for three skill-groups. The data originate from the individual statistical offices and were then harmonized to the same industry levels, reference years, and categorizations of capital and labor specifications by the EU KLEMS project. The coverage varies by country, by industry, and for the individual variables. The variables used in this study are listed in table 17. The set of countries used in this study is listed in table 18, the set of industries is described in table 19. The 21 industries used here cover most of the countries' private economic activity including service sectors. Sectors which are mostly public or non-tradeable are left out of the analysis. This dataset is more homogeneous as the countries are rather with respect to technology, institutions, openness and the general wage setting conditions. As a robustness check, I later include data for Australia, Czech Republic, Japan, and the US as well as less tradeable, but private industries.

The labor share is defined as the total labor compensation over value added. The wage bill in the EU KLEMS is total labor compensation adjusted for the amount of self-employed, where it is assumed that the wage of self-employed equals the wage of employees in the same sector in the respective country. The labor share is not necessarily restricted to be between 0 and 1. In some circumstances the share can exceed total value added of the industry in some periods if there are losses in the period or if the income of self-employed is over estimated. Also subsidies may affect value added. EU KLEMS accounts for some subsidies such as price subsidies. Other subsidies are much harder to identify and to calculate into value added. In nine industry-country-combinations I found labor shares above one for more than 8 years which would be longer than a full business cycle. I leave this industry-country-combinations out of the analysis as they are likely to be subject to measurement errors. Table 20 shows the summary statistics for the labor share across industries. The labor share tends to be lowest in the Mining and Quarrying sector and Electricity, Gas, and Water Supply. The labor share in service sectors varies strongly from 2.4 to 166 percent of value added in the industry. Manufacturing is the largest subgroup and also contains very heterogeneous industries with respect to the labor share.

In order to find the driving forces of changes in the overall labor share and for a more detailed analysis, I also calculate the individual share of total value added that is payed out in wages to either high-skilled workers, medium- and low-skilled workers, or low-skilled workers only. For these variables I multiply the labor share with the relative compensation of workers of each skill group. The relative compensation shares are the shares of all wages and salaries including all costs that are covered by the employer of the respective skill group. The skill groups are defined by the level of education of the workers. As educational systems vary across the relevant countries, the definitions of who belongs to which skill group differ slightly. Generally, workers with a college degree are counted as high-skilled workers, workers with upper secondary education, some college or a vocational degree are counted as medium-skilled, and workers with at most secondary education or no formal qualifications are counted as low-skilled workers.[10]

The data for technology variables, capital stock and ICT capital investments, are also taken from the EU KLEMS. Capital stocks are measured as the real gross fixed capital stocks of the industry. ICT-capital investments are defined as real gross fixed capital formation of ICT assets and are also provided on the industry level. ICT is considered as office and computing equipment, communication equipment, and software. The share of each kind of capital in value added varies tremendously across industries, but usually increases over the whole time frame. As table 21 shows, both capital stock and ICT investment are either a fraction of value added or may even be as large as a multitude of the value added of the respective industry.

The remaining data on institutions, unemployment, and trade are on the country level. The data for trade flows and economic restrictions are taken from the KOF Index of Globalization by Dreher (2006). The KOF Index consists of three subcategories, economic globalization, social globalization, and political globalization. In this study I employ the two indexes of economic globalization: trade flows and trade restrictions. Both indexes are measured on a scale between 0 and 100 and increase with more openness (higher trade flows or less trade restrictions). The first, trade flows, is constructed from the classical openness variable, imports plus exports over GDP, as well as FDI, portfolio investments and income payments to foreign nationals. I refer to this variable as "openness". The index for restrictions on trade and capital is constructed from data on mean tariff rates, taxes on international trade, capital account restrictions, and hidden import barriers. This index is called "restrictions" in this study. It is based on indexes of rules and regulations, such as the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions. It therefore measures rather capital account openness and potential openness with respect to flows. Although there exists some data for openness on a sectoral level in the OECD STAN database, the data quality is much better on the

[10] A detailed description of the definitions of skill levels for each country, as used in this study, can be found in Timmer et al. (2007b), page 28.

country level, as there are no missing values. The trade flows and restrictions give a broad picture of actual and potential openness of a country. They are correlated with 0.72, but, as the last lines of table 21 show, the trade flows measure has a much larger variance for the countries and time frame of interest in this study.

The information about labor market institutions are again collected from different datasets. Unemployment benefits are the first-year gross replacement rates. The information of the gross replacement rates are taken from the FRDB Database of Structural Reforms (2010). Here, the first year gross replacement rates are used. Data on unemployment rates are taken from the KILM database of the ILO (2010). I use the data on union coverage from the ICTWSS of the University of Amsterdam (Visser, 2008).

4.4 Empirical Results

In this section I first explore the impact of the various regressors on the labor share using country level data. This lets me compare the results to similar studies and indicates relationships of the regressors and the overall labor share which includes shifts between industries. Afterwards, I will come to the main results of the paper and investigate how the industry level labor shares are affected by the regressors, whether this is driven by individual skill-groups characteristics, and in which way the impacts differ between manufacturing and service industries.

4.4.1 Influences on the Country-Level

Similar to the studies by the European Commission (2007) and Checchi and Garcia-Penalosa (2010), I estimate the impact of the technological, institutional and trade influences at the labor share on a country level. The results are shown in table 4.1. The upper part of the table shows the long-run relationships between the labor share and the regressors, while the lower parts contain the short-run dynamics. These results are mostly in line with the studies by the European Commission (2007) and Checchi and Garcia-Penalosa (2010). An exception is the short-run positive impact of openness where the European Commission (2007) find a negative significant long-run impact. It should be noted, though, that the other studies only focus on the long-run effects in levels and leave short-run dynamics out of the picture.

Table 4.1: Regression on the Country Level

Dependent Variable: First Difference of the Log Labor Share	
$ln\ s_{L,t-1}$ *	-0.360***
	(0.043)
$ln\ (K/Y)_{t-1}$	0.144***
	(0.043)
$ln\ \left(K^{ICT}/Y\right)_{t-1}$	-0.008
	(0.008)
$ln\ union_{t-1}$	0.043***
	(0.015)
$ln\ unben_{t-1}$	-0.008***
	(0.002)
$ln\ u_{t-1}$	-0.013*
	(0.007)
$ln\ rest_{t-1}$	-0.027
	(0.041)
$ln\ open_{t-1}$	-0.042**
	(0.018)
$\Delta\ ln\ (K/Y)_t$	0.692***
	(0.048)
$\Delta\ ln\ (K/Y)_{t-1}$	0.009
	(0.073)
$\Delta\ ln\ (K/Y)_{t-2}$	-0.207***
	(0.053)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_t$	-0.002
	(0.011)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_{t-1}$	0.029**
	(0.012)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_{t-2}$	0.011
	(0.015)
$\Delta\ ln\ union_t$	0.026
	(0.029)
$\Delta\ ln\ union_{t-1}$	0.117***
	(0.028)
$\Delta\ ln\ union_{t-2}$	0.039
	(0.026)

Continued on next page

Table 4.1 – *continued from previous page*

Δ *ln* $unben_t$	-0.003**
	(0.001)
Δ *ln* $unben_{t-1}$	0.006***
	(0.002)
Δ *ln* $unben_{t-2}$	0.008***
	(0.002)
Δ *ln* u_t	-0.022**
	(0.009)
Δ *ln* u_{t-1}	-0.007
	(0.011)
Δ *ln* u_{t-2}	-0.002
	(0.008)
Δ *ln* $rest_t$	-0.007
	(0.049)
Δ *ln* $rest_{t-1}$	0.010
	(0.059)
Δ *ln* $rest_{t-2}$	-0.032
	(0.051)
Δ *ln* $open_t$	-0.016
	(0.018)
Δ *ln* $open_{t-1}$	0.038***
	(0.014)
Δ *ln* $open_{t-2}$	0.020
	(0.019)
cons	-0.257
	(0.173)
$time - trend$	✓
$time - trend^2$	✓
N	157
r2	0.669

Cluster robust standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The coefficient on $lns_{L,t-1}$ is equivalent to the error-correction speed of adjustment parameter. It is significant at any conventional level which indicates a long-run relationship between the regressors and the dependent variable. There is long-run positive coefficient for the capital-output ratio. This indicates a complementarity between capital and labor in production. The short-run impacts of the capital-output ratio can be found at the beginning of the lower part of the table. In the short-run the labor share also increases strongly after increased investments into capital, while after two periods the positive impact is partly reversed. This is explainable by the idea of sunk investment costs which were discussed at the end section 4.2.1. If capital and labor are complements and bargaining takes place after capital is invested, the labor share rises since the workers can then secure a high share of the rents under increased revenues with a higher output. Afterwards, employment and wages will be adjusted such that some of the increased rents will return to the capital owners.

ICT-capital seems to have a small and non-persistent positive short-run impact on the labor share in European countries on the country-level. Union coverage, on the other hand, has a persistent positive impact on the labor share as it stands for higher possible rents for workers due to higher bargaining power. Increases in unemployment benefits also has long- and short-run impacts on the labor share. The positive short-run dynamics could indicate a immediate increase in wages while employment is not adjusted immediately. In the long-run employment is then adjusted to the higher wages such that the labor share even decreases. Unemployment reduces the labor share in the short- and long-run. Thus, as cyclical increase in the unemployment rate decreases the labor share while high-persistent unemployment will also decrease the labor share in the long-run. Increases in trade flows increase the labor share with a one period lag, while trade restriction have no impact on the country level.

4.4.2 Influences on the Industry-Level

Table 4.2 shows the results for an within-industry (i. e. fixed effects) estimation which includes 21 tradeable industries in 9 European countries. The first column displays the results for the estimation on the industry-level labor share which are the main results. The next three columns have the same regressors, but the dependent variable is the labor share of a specific skill group. The last two columns contain results of separate estimations for the manufacturing and service sector. As there are differences in the tradeablity of output in manufacturing and services as well as in the institutional structures, such as higher union coverage in manufacturing, splitting the sample by sector may indicate how the regressors influence the labor shares in detail.

Within-Industry Estimation

For the overall labor share the error-correction adjustment term is again significant and negative and has roughly the same size as for the country-level regression. There is a significant positive coefficient for the capital-labor ratio which indicates a persistent complementary relationship of the two input factors. This is clearly in line with SK-schedule described by Bentolia and Saint-Paul (2003), although they find indications of substitutability between capital and labor rather than complementarity. Furthermore, economic openness has strong persistent influences on the labor share. A reduction in trade restrictions (*ln rest* increases) as well as increasing trade flows both decrease the labor share in the long-run. As described in the theory part, this can be due to an improving outside option of the firm and thus substitutability of workers across countries, or due to weakened competition on the product market. The coefficient on the long-run restriction variable is quite large. Here it has to be taken into account that this variable increases roughly a quarter to a third between 1980 and 2005 while openness, which signifies trade flows, doubles or tripled for most countries. Both globalization variables also have short-run dynamics on the labor share. A decrease in restrictions has an immediate negative impact on the labor share, while the very first negative impact of increasing trade flows is dampened by a positive lagged impact which is about the same size.

Table 4.2: Results for Main Regression, by Skill Group, and by Sector

Dependent Variables: First Difference of the Log Labor Share of the industry, the Respective Skill Group, or Sector of industry j in country i						
	Overall	High	Med. & Low	Low	Manuf.	Services
$ln\ s^i_{L,t-1}$	-0.295***	-0.198***	-0.278***	-0.134*	-0.318***	-0.239***
	(0.044)	(0.064)	(0.044)	(0.073)	(0.056)	(0.013)
$ln\ (K/Y)_{t-1}$	0.057*	0.037	0.067***	0.057*	0.055	0.073***
	(0.030)	(0.035)	(0.024)	(0.029)	(0.043)	(0.016)
$ln\ \left(K^{ICT}/Y\right)_{t-1}$	0.005	0.013	0.008	0.002	-0.002	0.015***
	(0.008)	(0.010)	(0.007)	(0.013)	(0.013)	(0.003)
$ln\ union_{t-1}$	0.025	-0.084***	0.041**	0.155***	0.017	0.044**
	(0.018)	(0.022)	(0.016)	(0.047)	(0.020)	(0.019)
$ln\ unben_{t-1}$	-0.001	-0.017**	0.003	-0.056**	-0.000	-0.002
	(0.002)	(0.007)	(0.003)	(0.025)	(0.003)	(0.003)
$ln\ u_{t-1}$	0.015	-0.011	0.000	0.011	0.017	0.010
	(0.014)	(0.015)	(0.012)	(0.017)	(0.018)	(0.009)
$ln\ rest_{t-1}$	-0.158**	-0.031	-0.105*	-0.177	-0.185**	-0.079
	(0.063)	(0.103)	(0.058)	(0.194)	(0.074)	(0.097)
$ln\ open_{t-1}$	-0.070**	-0.057	-0.062	0.037	-0.063**	-0.083**
	(0.033)	(0.056)	(0.046)	(0.081)	(0.032)	(0.041)
$\Delta\ ln\ (K/Y)_t$	0.335***	0.357***	0.334***	0.345***	0.331***	0.416***
	(0.110)	(0.107)	(0.111)	(0.119)	(0.122)	(0.038)
$\Delta\ ln\ (K/Y)_{t-1}$	0.123*	0.111	0.114	0.089	0.147**	-0.010
	(0.070)	(0.077)	(0.072)	(0.076)	(0.070)	(0.028)
$\Delta\ ln\ (K/Y)_{t-2}$	-0.015	-0.042	-0.027	-0.060	-0.008	-0.010
	(0.048)	(0.052)	(0.050)	(0.058)	(0.057)	(0.034)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_t$	-0.009	-0.028*	-0.003	-0.003	-0.013*	-0.006
	(0.007)	(0.017)	(0.008)	(0.014)	(0.008)	(0.005)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_{t-1}$	-0.007	-0.011	-0.009	-0.007	-0.011	0.007
	(0.008)	(0.017)	(0.008)	(0.006)	(0.010)	(0.010)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_{t-2}$	0.006	0.012**	0.006	0.016	0.010	-0.013
	(0.007)	(0.006)	(0.008)	(0.010)	(0.008)	(0.009)
$\Delta\ ln\ union_t$	0.095*	-0.259**	0.139***	0.310***	0.186***	-0.065
	(0.049)	(0.132)	(0.044)	(0.082)	(0.056)	(0.068)
$\Delta\ ln\ union_{t-1}$	0.219**	0.285**	0.164**	0.241	0.237*	0.214***
	(0.085)	(0.136)	(0.077)	(0.150)	(0.130)	(0.039)
$\Delta\ ln\ union_{t-2}$	0.050	-0.089	-0.013	0.368***	0.094	-0.033
	(0.061)	(0.142)	(0.057)	(0.142)	(0.084)	(0.045)

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Table 4.2 – *continued from previous page*

	Overall	High	Med. & Low	Low	Manuf.	Services
Δ *ln* $unben_t$	0.002	0.007*	0.006	-0.015	0.009	-0.012**
	(0.005)	(0.004)	(0.004)	(0.015)	(0.006)	(0.005)
Δ *ln* $unben_{t-1}$	0.008**	0.018*	0.008**	0.036**	0.006	0.012***
	(0.004)	(0.010)	(0.003)	(0.016)	(0.005)	(0.002)
Δ *ln* $unben_{t-2}$	-0.002	0.009	-0.000	0.016*	-0.001	-0.004*
	(0.008)	(0.011)	(0.006)	(0.009)	(0.012)	(0.002)
Δ *ln* u_t	0.001	-0.016	-0.008	-0.012	0.011	-0.018
	(0.020)	(0.027)	(0.018)	(0.052)	(0.029)	(0.015)
Δ *ln* u_{t-1}	-0.035*	0.039	-0.030	-0.026	-0.037	-0.027**
	(0.020)	(0.057)	(0.019)	(0.030)	(0.026)	(0.012)
Δ *ln* u_{t-2}	-0.007	-0.005	0.005	-0.020	-0.001	-0.020*
	(0.020)	(0.049)	(0.019)	(0.020)	(0.028)	(0.011)
Δ *ln* $rest_t$	-0.164**	0.163	-0.221***	-0.397*	-0.238**	-0.005
	(0.070)	(0.225)	(0.077)	(0.209)	(0.109)	(0.082)
Δ *ln* $rest_{t-1}$	-0.047	-0.303	-0.055	-0.037	-0.096*	0.016
	(0.051)	(0.227)	(0.053)	(0.222)	(0.056)	(0.094)
Δ *ln* $rest_{t-2}$	-0.021	0.175	-0.050	0.345	-0.083	0.108
	(0.081)	(0.201)	(0.075)	(0.393)	(0.115)	(0.080)
Δ *ln* $open_t$	-0.074***	-0.114***	-0.061*	-0.000	-0.090***	-0.048
	(0.025)	(0.033)	(0.031)	(0.068)	(0.024)	(0.035)
Δ *ln* $open_{t-1}$	0.030	-0.046	0.041	0.024	0.019	0.048**
	(0.026)	(0.097)	(0.030)	(0.062)	(0.036)	(0.020)
Δ *ln* $open_{t-2}$	0.042***	0.027	0.053***	0.078*	0.037*	0.041**
	(0.014)	(0.048)	(0.014)	(0.046)	(0.020)	(0.020)
cons	0.678**	1.873***	2.949***	1.149	0.734**	0.505
	(0.268)	(0.716)	(0.541)	(1.001)	(0.305)	(0.386)
$time - trend$	✓	✓	✓	✓	✓	✓
$time - trend^2$	✓	✓	✓	✓	✓	✓
N	3259	3259	3259	3259	2160	1099
r2	0.299	0.220	0.288	0.266	0.304	0.334

Cluster robust standard errors in parentheses with two-way clustering on country and industry-country level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Union coverage, unemployment benefits, and the unemployment rate have only short-run dynamic effects on the labor share on the industry-level. As expected union coverage has a positive influence and this is strongest one period after the increase. Unemployment benefits have a smaller, but still positive impact on the labor share. This positive impact of the outside option of the worker is also lagged one period. A higher unemployment rate decreases the labor share one period later. As both, the labor share and the unemployment rate, tend to be countercyclical,[11] this estimation indicates that an increase in the unemployment rate will dampen the countercyclical movement of the labor share. An explanation would be that an increase in the unemployment rate will clearly have less people employed and the ones who are employed ask for lower wages.

Within-Industry Estimation for Separate Skill Groups

All influences of the labor share, discussed in this study may have a different effect for each skill-group. Technological progress may be skill-biased and also trade may affect the labor market outcomes workers differently depending on their skills and productivity.[12] As technology may be complementary to some skills and substitutes to others or labor market institutions favoring specific worker groups, differences in the regressions can be expected. The literature concerned with skill-biased technological change assumed a linear relationship between skill and technological progress in ICT. Here it is assumed that low-skilled work is a substitute to technology while high-skilled work in complementary. Checchi and Garcia-Penalosa (2010) assume this even for non-ICT capital. A more recent literature is concerned with substitution of work at the middle of the income and skill distribution. This literature argues that specific tasks are substitutes to ICT, which are mostly prevalent in medium-skilled work. The result for high-skilled workers' labor share can be found in the second column of table 4.2, for medium and low-skilled in column three, and only for low-skilled only in the last column.

The results show remarkable differences between the skill-groups. The high-skilled labor share has no long-run relationship with technological or trade variables. Only labor market institutions seem to have lasting and negative influences on the labor share of high-skilled. Union coverage has a negative long-run influence on the labor share although it should represent bargaining power. This can be explained by the tendencies of unions to compress wages and decrease wage inequality in unionized settings (Acemoglu et al., 2001). Indeed there is a stronger positive impact on union coverage on the labor share for low-skilled and only much smaller effects in the estimation for medium and low-skilled labor share. Thus, although union coverage has a strong connection to the labor share for individual skill groups, the effect levels out between the group such that it disappears on the aggregate level. Unemployment benefits also reduce the labor share

[11] C.f. European Commission (2007), Choi and Ríos-Rull (2009), or Ríos-Rull and Santaeulàlia-Llopis (2010).

[12] For a review on skill-biased technological change see Katz and Autor (1999), Braun et al. (2009), or Acemoglu and Autor (2011) for a more recent approach. A survey on the impact of international trade on labor markets can be found in Johnson and Stafford (1999).

in the long-run although its short-run dynamic is positive. This indicates that at first wages increase due to a higher alternative wage, $\overline{w}$, but in the longer-run employment is adjusted such that the labor share decreases. As low-skilled workers' wages tend to be smaller, the outside option of unemployment benefits should have a higher probability to be binding and thus their coefficient should be larger, which is indeed the case.

Although high-skilled workers' labor share has no significant long-run relationship with the capital-output ratio, the immediate impact of an increase in the capital-output ratio is highly positive and significant and also very close to the impact it has on the labor share of workers with less education. For the high-skilled, ICT-investments reduce the labor share in the beginning, but weakens the impact through a smaller positive impact after two periods. The long-run relationship, which mirrors the SK-schedule is significant for the medium and low-skilled workers. The results indicate that medium and low-skilled work is complementary to capital. Even though ICT-investments have no long-run impact on the labor share, the significant negative short-run dynamic for the high-skilled is interesting as it is usually assumed that ICT is skill biased towards high-skilled workers, while it substitutes low-skilled work.

Differences between skill groups can also be found for the impact of economic openness on the respective labor shares. While there are strong negative long-run impacts of trade flows and restrictions for the overall labor share, a negative significant impact is only found for decreasing trade restrictions on the medium and low-skilled labor share. No other coefficients for the long-term impacts are significant. Decreasing trade restrictions have an immediate negative impact on the labor share for medium and low-skilled workers. Especially the coefficient for trade restrictions on the low-skilled labor share is large. While a reduction in barriers to trade, such as decreasing import barriers and taxes on trade or increasing capital account openness, affects mostly medium and low-skilled workers' labor share, increasing trade flows influence the high-skilled workers' labor share negatively. Trade flows reduce the high-skilled workers' share in the first period, but become insignificant thereafter and in the long-run. The medium and low-skilled workers' share is also reduced at first, but this effect is almost undone two periods later when openness increases the share again. For low-skilled workers trade openness has only a positive impact on their share two periods after an increase. For both openness variables the negative effects on the separate skill groups outweigh potential positive effect, as the overall long-run impact and the very short-run dynamics are negative.

Within-Industry Estimation for Manufacturing and Services

Next to differences in the influences on the bargaining outcome for the skill groups, bargaining outcomes may vary between sectors. Tradeable industries in manufacturing are likely to differ in the wage and employment setting mechanisms from service industries. I therefore estimate the error-correction model individually for tradeable manufacturing and tradeable service industries in Europe. The estimation results can be found in the last two columns of table 4.2.

Although the coefficient for the long-run relationship between capital and the labor share are similar and positive in both regressions, it is only significant for the service industries. The short-run dynamics also indicate capital-labor complementarity. While for services the first-year effect is stronger, increasing the capital stock relative to output has a significant positive impact for the following two periods. The negative third period effect of the capital-output ratio on the labor share which was observable in the country level regression of the last column in table 4.1 has not been significant for any industry-panel regression. ICT-capital investments have very different impact in services compared to manufacturing. In services, ICT-investments increase the labor share in the long-run and thus are complementary to labor while in manufacturing increases in ICT have an immediate negative impact. In manufacturing there is an short-run substitution effect without long-run consequences for the labor share.

Surprisingly, unions have a long-run positive impact only in services although union coverage tends to be higher in manufacturing (Machin, 2000). Nevertheless, an increase of bargaining power due to an increase in coverage has a positive short-run impact for the labor share in both sectors.

Trade integration has negative long-run impacts on the labor share in services and manufacturing although decreasing trade restrictions only affect manufacturing industries. This negative impact is observable in the short- and in the long-run. Increasing trade flows have long-run negative impact in both sectors while the short-run dynamics differ. In manufacturing increasing trade flows first decrease the labor share, but this dampened is in the third period by a smaller increase. The short-run dynamics in services, on the other hand, are positive.

Wage Markups in Europe

The outside option for the firm under trade openness is more valuable if wages in countries with similarly skilled workers are lower. Therefore, I include a measurement for the wage-markup of industry j in country i compared to industry j in all other European countries.

$$ln\ markup_{ijt} = ln \left(\frac{w_{ijt}}{\frac{1}{I} \sum_i w_{ijt}} \right) \tag{4.12}$$

where w is the average hourly wage of industry j in country i and $I = \sum i$.

Having similar educational backgrounds across Europe, a higher markup for a country, raises incentives for firms to offshore production to another European country. A higher markup is therefore expected to lower the bargaining outcome for workers. If wages are much higher in the respective country, workers should have an incentive to reduce wages in order to keep the production process at home. In the long-run wages should therefore equalize if labor is homogeneous across countries and barriers to trade are reduced.

The wage markup is endogenous in the estimation as the wage w appears on the left side of the equation in the labor share, ($s_L = wL/Y$), and on the right side in the markup. I therefore construct an instrument. It is the average hourly wage of industry j in Europe[13] excluding the respective country at time t.

$$instrument_{ijt} = \frac{1}{I-1} \sum_{i \backslash m} w_{ijt} \tag{4.13}$$

Table 4.3 shows the estimation with a markup in the first column and the IV regression in the second. The first column shows how including wages biases the regression coefficients. Under the IV estimation the coefficients return to the values and significance levels as in the baseline regression of the first column in table 4.2. The dynamics of the markup coefficients show that higher wages compared to other countries lead to a lower bargaining outcome over the labor share for workers.[14] This will hence indeed lead to an equalization of wages in the European countries.

[13] For the construction of this variable I calculate the average industry wages for all European countries which are available in the EU KLEMS at time t.

[14] In this estimation a level effect of the markup is not included as wages should equalize in the long run. If it is included, the coefficients and significance levels of all other coefficients remain the same while the coefficient on the level variable is small and highly insignificant.

Table 4.3: Markup and IV Regression

Dependent Variable: First Difference of the Log Labor Share		
	Markup	IV
$ln\ s_{L,t-1}$	-0.194***	-0.305***
	(0.021)	(0.049)
$ln\ (K/Y)_{t-1}$	0.048*	0.061**
	(0.028)	(0.029)
$ln\ \left(K^{ICT}/Y\right)_{t-1}$	0.005	0.004
	(0.008)	(0.007)
$ln\ union_{t-1}$	0.018	0.032*
	(0.015)	(0.019)
$ln\ unben_{t-1}$	-0.004	0.003
	(0.003)	(0.002)
$ln\ u_{t-1}$	0.020*	0.022
	(0.011)	(0.014)
$ln\ rest_{t-1}$	-0.107	-0.162***
	(0.070)	(0.054)
$ln\ open_{t-1}$	-0.029	-0.136***
	(0.040)	(0.045)
$\Delta\ ln\ markup_t$	0.370***	-0.136***
	(0.058)	(0.046)
$\Delta\ ln\ markup_{t-1}$	-0.079***	-0.114***
	(0.022)	(0.033)
$\Delta\ ln\ markup_{t-2}$	-0.001	-0.014
	(0.029)	(0.042)
$\Delta\ ln\ (K/Y)_t$	0.549***	0.260**
	(0.068)	(0.120)
$\Delta\ ln\ (K/Y)_{t-1}$	0.014	0.078
	(0.033)	(0.067)
$\Delta\ ln\ (K/Y)_{t-2}$	-0.058	-0.002
	(0.038)	(0.058)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_t$	-0.021***	-0.005
	(0.007)	(0.008)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_{t-1}$	-0.001	-0.004
	(0.006)	(0.009)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_{t-2}$	0.009	0.007
	(0.007)	(0.008)

Continued on next page

Table 4.3 – *continued from previous page*

	Markup	IV
$\Delta\ ln\ union_t$	0.090	0.124
	(0.092)	(0.081)
$\Delta\ ln\ union_{t-1}$	0.107	0.239***
	(0.086)	(0.082)
$\Delta\ ln\ union_{t-2}$	0.115**	0.022
	(0.048)	(0.054)
$\Delta\ ln\ unben_t$	-0.004	0.001
	(0.006)	(0.005)
$\Delta\ ln\ unben_{t-1}$	0.008*	0.007*
	(0.004)	(0.004)
$\Delta\ ln\ unben_{t-2}$	0.004	-0.004
	(0.006)	(0.009)
$\Delta\ ln\ u_t$	-0.000	0.012
	(0.020)	(0.020)
$\Delta\ ln\ u_{t-1}$	-0.011	-0.051**
	(0.019)	(0.026)
$\Delta\ ln\ u_{t-2}$	-0.064***	0.007
	(0.022)	(0.022)
$\Delta\ ln\ rest_t$	0.008	-0.186**
	(0.119)	(0.079)
$\Delta\ ln\ rest_{t-1}$	-0.052	-0.097
	(0.092)	(0.081)
$\Delta\ ln\ rest_{t-2}$	0.178*	-0.104
	(0.094)	(0.110)
$\Delta\ ln\ open_t$	-0.001	-0.125***
	(0.035)	(0.040)
$\Delta\ ln\ open_{t-1}$	0.065***	0.012
	(0.021)	(0.026)
$\Delta\ ln\ open_{t-2}$	-0.045	0.065***
	(0.049)	(0.023)
cons	0.418	0.842***
	(0.287)	(0.258)
$time-trend$ and $time-trend^2$	✓	✓
N	3259	3259
r2	0.508	0.158

Cluster robust standard errors in parentheses with two-way clustering on country and industry-country level.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4.4: Fixed Effects Regression of ICT on Openness

Dependent Variable: Log of Trade Flows and Log of Trade Restrictions		
	ln open	*ln rest*
$ln\ \left(K^{ICT}/Y\right)$	0.169***	0.067***
	(0.033)	(0.012)
cons	4.776***	4.711***
	(0.129)	(0.0446)
N	4045	4045
r2	0.512	0.569

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Interaction between ICT-Investments and Globalization

The trade literature traditionally asks the questions under which circumstances a firm decides to offshore production through offshore outsourcing or FDI. Grossman and Rossi-Hansberg (2008) discuss how technological progress in transportation as well as in ICT raise incentives to separate production processes across economies. ICT enables communication with offshored subsidiaries, enables service offshoring, lowers transportation costs especially for services and increases monitoring possibilities (Braun et al., 2009, Part II). As economic openness and ICT are closely interconnected, it is interesting to study both impacts on the labor share together. Table 4.4 shows the within-industry correlations between ICT-investments and trade flows and trade restrictions respectively. ICT-investments and flows have positive correlation which is significant on any conventional level. The correlation between ICT-investments and trade restrictions, which is rather a measurement for potential openness, is similarly positive and significant, only somewhat smaller. These results imply that the regression results for the openness variables include variation from ICT investments. Next, I estimate the error-correction model and interact both globalization variables with investments in ICT to be able to distinguish between individual and joint effects of the variables on the labor share.

Table 4.5 shows the results of the interactions. In the first column the variable trade restriction is interacted with the ICT-investments-output ratio. This regression shows a strong interconnection between the reduction of trade restrictions and ICT-investments in their impact on the labor share. A simultaneous increase in both has a long-run negative and significant impact on the labor share. The long-run individual impact of decreasing trade restrictions is actually more than twice the size of the negative coefficient without the interaction. The results also show a long-run complementarity between labor and ICT-capital. Without the common variation between ICT-capital investments and restrictions on economic openness the impact of ICT-investments on the labor share is positive and large in the long-run dynamics. All short-run dynamics of restrictions and ICT-investments become insignificant with the interactions. These results imply that ICT-investments have a negative impact on the labor share in that they enable offshoring and relocation of production processes abroad. The negative common impact of the interaction show how ICT decreases the labor share through an improvement of the outside option of the firm (D increases). The direct technological impact increases the labor share as it is labor augmenting.

Table 4.5: Interactions Between Globalization and ICT

Dependent Variable: First Difference of the Log Labor Share
Estimation for Europe

	ICT & Rest.	ICT & Open.	ICT & Rest.	
	Full Sample		Services	Med.+Low
$ln\ s_{L,t-1}$	-0.297***	-0.296***	-0.244***	-0.285***
	(0.045)	(0.045)	(0.014)	(0.045)
$ln\ \left(K^{ICT}/Y\right)_{t-1} * ln\ rest_{t-1}$	-0.053**		-0.049**	-0.083***
	(0.022)		(0.021)	(0.029)
$ln\ \left(K^{ICT}/Y\right)_{t-1} * ln\ open_{t-1}$		-0.012		
		(0.012)		
$ln\ (K/Y)_{t-1}$	0.057*	0.058*	0.075***	0.068***
	(0.031)	(0.031)	(0.017)	(0.026)
$ln\ \left(K^{ICT}/Y\right)_{t-1}$	0.241**	0.051	0.224**	0.373***
	(0.094)	(0.040)	(0.093)	(0.127)
$ln\ union_{t-1}$	0.023	0.029	0.043**	0.037**
	(0.019)	(0.022)	(0.017)	(0.016)
$ln\ unben_{t-1}$	-0.003	-0.003	-0.005*	-0.000
	(0.003)	(0.003)	(0.003)	(0.002)
$ln\ u_{t-1}$	0.011	0.011	0.005	-0.006
	(0.015)	(0.014)	(0.009)	(0.013)
$ln\ rest_{t-1}$	-0.356**	-0.154**	-0.267*	-0.419***
	(0.142)	(0.066)	(0.149)	(0.151)
$ln\ open_{t-1}$	-0.062*	-0.117*	-0.075**	-0.049
	(0.032)	(0.069)	(0.037)	(0.044)

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Table 4.5 – *continued from previous page*

	ICT & Rest.	ICT & Open.	ICT & Rest.	
	Full Sample		Services	Med.+Low
$\Delta\, ln\, \left(K^{ICT}/Y\right)_t * ln\ rest_t$	-0.124		-0.034	-0.148
	(0.116)		(0.066)	(0.127)
$\Delta\, ln\, \left(K^{ICT}/Y\right)_{t-1} * ln\ rest_{t-1}$	0.015		0.137	0.012
	(0.066)		(0.087)	(0.062)
$\Delta\, ln\, \left(K^{ICT}/Y\right)_{t-2} * ln\ rest_{t-2}$	0.029		0.063	0.041
	(0.083)		(0.041)	(0.074)
$\Delta\, ln\, \left(K^{ICT}/Y\right)_t * ln\ open_t$		-0.004		
		(0.019)		
$\Delta\, ln\, \left(K^{ICT}/Y\right)_{t-1} * ln\ open_{t-1}$		0.012		
		(0.019)		
$\Delta\, ln\, \left(K^{ICT}/Y\right)_{t-2} * ln\ open_{t-2}$		0.004		
		(0.008)		
$\Delta\, ln\, (K/Y)_t$	0.336***	0.336***	0.414***	0.336***
	(0.108)	(0.110)	(0.039)	(0.109)
$\Delta\, ln\, (K/Y)_{t-1}$	0.125*	0.125*	-0.009	0.117
	(0.070)	(0.070)	(0.028)	(0.071)
$\Delta\, ln\, (K/Y)_{t-2}$	-0.015	-0.014	-0.005	-0.025
	(0.049)	(0.048)	(0.035)	(0.051)
$\Delta\, ln\, \left(K^{ICT}/Y\right)_t$	0.548	0.008	0.145	0.659
	(0.526)	(0.079)	(0.297)	(0.577)
$\Delta\, ln\, \left(K^{ICT}/Y\right)_{t-1}$	-0.071	-0.055	-0.604	-0.061
	(0.294)	(0.074)	(0.388)	(0.277)
$\Delta\, ln\, \left(K^{ICT}/Y\right)_{t-2}$	-0.123	-0.010	-0.294	-0.176
	(0.367)	(0.030)	(0.184)	(0.326)
$\Delta\, ln\ union_t$	0.099**	0.093**	-0.063	0.143***
	(0.047)	(0.047)	(0.069)	(0.041)
$\Delta\, ln\ union_{t-1}$	0.226**	0.218***	0.222***	0.178**
	(0.090)	(0.080)	(0.040)	(0.079)
$\Delta\, ln\ union_{t-2}$	0.061	0.047	-0.017	0.006
	(0.072)	(0.061)	(0.041)	(0.069)
$\Delta\, ln\ unben_t$	0.001	0.001	-0.013**	0.005
	(0.004)	(0.006)	(0.006)	(0.004)
$\Delta\, ln\ unben_{t-1}$	0.011***	0.009**	0.014***	0.011***
	(0.004)	(0.004)	(0.002)	(0.004)
$\Delta\, ln\ unben_{t-2}$	-0.000	-0.002	-0.004	0.002
	(0.007)	(0.008)	(0.002)	(0.005)

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Table 4.5 – *continued from previous page*

	ICT & Rest.	ICT & Open.	ICT & Rest.	
	Full Sample		Services	Med.+Low
$\Delta\ ln\ u_t$	-0.003	-0.002	-0.023	-0.015
	(0.019)	(0.018)	(0.015)	(0.016)
$\Delta\ ln\ u_{t-1}$	-0.035*	-0.033*	-0.027**	-0.030*
	(0.019)	(0.019)	(0.012)	(0.017)
$\Delta\ ln\ u_{t-2}$	-0.005	-0.005	-0.017*	0.007
	(0.019)	(0.020)	(0.009)	(0.018)
$\Delta\ ln\ rest_t$	-0.554	-0.151**	-0.084	-0.682
	(0.395)	(0.062)	(0.217)	(0.449)
$\Delta\ ln\ rest_{t-1}$	0.018	-0.047	0.435	0.015
	(0.247)	(0.050)	(0.274)	(0.235)
$\Delta\ ln\ rest_{t-2}$	0.092	-0.013	0.348**	0.118
	(0.288)	(0.086)	(0.147)	(0.249)
$\Delta\ ln\ open_t$	-0.073***	-0.092	-0.052	-0.061*
	(0.027)	(0.088)	(0.034)	(0.033)
$\Delta\ ln\ open_{t-1}$	0.028	0.077	0.037**	0.038
	(0.025)	(0.091)	(0.018)	(0.028)
$\Delta\ ln\ open_{t-2}$	0.038**	0.061	0.037**	0.047***
	(0.015)	(0.045)	(0.018)	(0.013)
cons	1.555***	0.841**	1.312**	4.398***
	(0.552)	(0.332)	(0.626)	(0.912)
$time - trend$	✓	✓	✓	✓
$time - trend^2$	✓	✓	✓	✓
N	3259	3259	1099	3259
r2	0.301	0.299	0.342	0.293

Cluster robust standard errors in parentheses with two-way clustering on country and industry-country level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Trade flows and ICT, on the other hand, seem to have no common impact on the labor share in this sample. The results of their interaction can be found in the second column of table 4.5. The common coefficient is insignificant for the long-run as well as the short-run dynamics. The individual impacts of ICT remain insignificant and the coefficients for openness are hardly affected by the interaction.[15] As mentioned above,

[15] These results seem to hold only for Western Europe. Including the Australia, Japan, the Czech Republic, and the US the effect disappears, even if only the 21 tradeable industries are considered. Furthermore, if ICT and trade flows are interacted, the interaction term is positive while the ICT-output ratio is negative. This would indicate a substitutability of ICT investments to labor in these countries. The aforementioned results for Western Europe hold also if industries which are less tradeable are included, although the coefficients are smaller and significant on a lower level.

this is not surprising as the impact of ICT on trade flows is already realized when trade takes place and therefore included in flows variable.

In order to find out if the results for the common impact of restrictions and ICT are driven by a sector or skill-group, I reestimate the regression for manufacturing and services separately and then for the individual skill groups. With respect to sectors, the common impact is mostly observable in the service sector. The estimation results for services are given in the third column of table 4.5. The coefficients for the common impact and the individual impacts are a bit smaller, but very similar and significant. The interaction variable has no significant results for manufacturing. Similarly, high and low-skilled worker seem to be not affected by the interaction, but for medium-skilled workers the impact is even much larger than in the overall regression. The results show that especially medium-skilled work is complementary to ICT, but they are also most threatened to loose shares of the overall income due to increasing capital mobility and economic integration.

Robustness: Estimation for Large Dataset

In order to find out how generalizable the Western European results are for other countries and more industries, I estimate the error-correction model for the large sample which includes Australia, the Czech Republic, Japan, and the US as well as other private sector industries which are less tradeable (see tables 18 and 19 for details on the large dataset). Tables 22 shows the estimation results.

The baseline results in column one of table 22 show very similar estimation results to the smaller sample. The coefficients on the capital-output ratio are a bit smaller and the short-run first period impact of ICT-capital investments are negative and significant. Unions have a smaller coefficient for the short-run dynamics, while they have a small but significant coefficient for the long-run impact. The coefficients for trade flows are a bit smaller, but most interestingly the coefficient for the long-run impact of trade restrictions much smaller and no longer significant. Across these heterogeneous industries and countries, economic globalization has only a long-run negative impact on the labor share through trade flows.

The results for the different skill groups are also similar to the ones from the smaller dataset. Regarding trade openness, a reduction in trade barriers has no long-run impact on the labor shares of any skill group in the large dataset. It only has an immediate negative impact on medium and low-skilled workers. Trade flows reduce the labor share of high and medium-skilled workers in the long-run, but has only significant negative short-run dynamics for medium-skilled workers.

Differences in large dataset compared to the baseline dataset with respect to manufacturing and services are apparent in the findings for ICT-capital investments, unemployment benefits, and economic globalization. ICT-capital investments only have an impact on the labor share in manufacturing in the larger dataset. Here it decreases the labor share in first periods after an increase, but has no lasting impact in the long-run. Unemployment benefits have countervailing effects in manufacturing and services. In levels and at impact, an increase in unemployment benefits increases the labor share in manufacturing, but it is decreased in services. This could indicate a more elastic labor demand in services on average in the larger dataset. In this dataset both openness variables have no impact on the labor share in services. In manufacturing and services both variables have a negative first period effect after an increase and trade flow reduce the labor share in manufacturing in the long-run as well. Here the coefficient is even larger than in the baseline dataset. Although economic integration has a common impact on the labor share in manufacturing, in services the impact depends on the specific industries and countries. In more tradeable industries and within Western Europe openness influences the bargaining outcome, while in other countries and more local service industries this is not observable.

Robustness: Structural Break

The mid 1990s were characterized by changes in the regulatory frameworks of international trade and economic integration as well as in technological progress. In 1993, the European internal market was finalized and the Maastricht Treaty came into effect. The Schengen Agreement was implemented in 1995, the same year the Uruguay round of the GATT ended and the WTO was founded. These regulations are intended to decrease barriers to trade, to integrate markets and increase competition. This will most likely have an impact on the labor markets as well. Furthermore, as Jorgenson (2001) discusses how from 1995 onwards, prices for semiconductors decreased and investments into ICT accelerated. Firpo et al. (2011) find changes in the impact of technology and trade on the occupational wage structure of men in the US between the 1980s, 1990s and 2000s. Therefore, it may be the case that the aforementioned results were mostly driven by the later or earlier period and that the results are not robust over time. I estimate the error-correction model by interacting all variables with dummies for the time period prior to 1994 and dummies for the time afterwards. The results can be found in table 23. I test for significant differences between the coefficients and indicate those by italic font.

It has to be taken into account that under split time periods the years of observation are very few to estimate long-run effects. There are hardly two business cycles in the estimation periods if the sample is split in 1994. For economic openness there are only a few significant differences between the two time periods. In manufacturing the negative impact of decreasing trade restrictions on the labor share intensifies in the short-run dynamics which has in effect on the aggregate estimation as well. Increasing trade flows increase the labor share in services in the short-run in the later period. The negative long-run impact remains. The influence of ICT-investments on the labor share changes mostly in the dynamics. A significant negative impact in the second period after an increase changed to a reduction of the labor share in the first period and an increase in the third for manufacturing and the overall labor share. In services an increase in ICT-investments decreases the labor share immediately in the later period while it was insignificant in the earlier period. An interesting observation is the change in the influence of unions on the labor share between the two periods. In manufacturing the positive long-run influence of higher union coverage on the labor share plummeted and became insignificant. In services union coverage became significant in the long-run only in the later period. As the time periods are very short for an error-correction framework, it is difficult to weigh these results very much. Nevertheless, there seems to be no drastic change in the relationship between economic openness and the labor share as well as between ICT-investments and the labor share in the two sub periods.

4.5 Conclusion

Increasing economic integration, frequent advances in information, and communication technology as well as changes in institutions have affected markets around the globe. How these changes have influenced labor markets in developed countries is of particular interest for researchers as well as policy makers. Governments have to come up with measures that secure competition and keep production local while ensuring that workers earn sufficiently and unemployment stays low. Implementing the appropriate measures demands a thorough understanding of the dynamics at hand. This paper aims at shedding light on these dynamics concerning the division of income between capital and labor.

The influences on the labor share are investigated by looking at short and long-run dynamics between 1980 and 2005. I show differences between the estimation on country and industry level. While estimating on a country level, which includes shifts in the sectoral composition within an economy, the labor shares in Western Europe are mostly influenced by the capital stock and labor market institutions as well as trade flows in the long-run. Analyzing labor shares on an industry level shows that institutions are less important overall for the distribution of income between capital and labor, but play a higher role in the distribution of income between skill groups. On an industry-level, the capital stock and economic integration determine the movements of the labor share in the long-run. The distributive impact of labor market institutions on the labor share for the different skill groups implies a compressionary impact of union involvement on the wage distribution. Unemployment benefits increase the labor share in the short-run, but as employment is adjusted, it has a negative impact on the long-run labor share which is especially strong for low-skilled workers. Contrary to studies of the European Commission (2007) or Arpaia et al. (2009), low and medium-skilled work are also found to be complementary to capital. The coefficients for the capital-output ratio are highly positive and similar for all skill groups.

The impact of globalization on the labor share is large and significantly negative in the short as well as the long-run. I use two kinds of measures for economic globalization. One accounts for trade flows, the other for a reduction in trade restrictions including capital account openness. On the industry-level, trade flows lower the labor share in the long-run significantly and trade-flows and decreasing trade restrictions also have negative short-run influences on the labor share. With respect to different skill groups, trade flows seem to affect rather the high and medium-skilled workers while medium and low-skilled workers labor shares are influenced by decreasing restrictions and capital market integration to a larger extend. Regarding manufacturing and services separately, the labor share in manufacturing industries are affected by both forms of economic integration in the short-run and strongly by increasing trade flows in the long-run. Services seem unaffected by economic integration on first sight. Correcting for common variation between technological advances in information and communication technology (ICT) and economic globalization shows that ICT enables economic integration and thus influences the labor share negatively. ICT-capital itself is complementary to labor and increases the labor share. This holds for Western Europe and especially for the service sector and medium-skilled workers' labor shares.

This result is especially interesting in the light of the labor market literature finding a polarization in many western economies. This polarization indicates decreasing wages for medium-skilled workers and workers who are in the middle of the wage distribution in general. Goos and Manning (2007) find such a polarization for the UK and Spitz-Oener (2006) and Dustmann et al. (2009) for Germany. These studies argue that the polarization is most likely due to innovations in ICT which complement specific tasks such as interactive and non-routine tasks and substitute routine tasks, which have a high fraction of total tasks in medium-skilled work. Autor et al. (2008) argue similarly for the observed polarization in the US, but also mention possible connections between ICT innovations and increasing economic integration. Grossman and Rossi-Hansberg (2008) translate the idea of tasks to the trade literature. Here specific tasks are more easily tradeable than others. Costinot et al. (2009) show that these tasks are indeed the ones which are more routine. Firpo et al. (2011) conclude from their analysis that both, ICT and trade, account an increasing polarization in the US, while ICT had it largest impact until the 1990s and trade became more important since the the 1990s. Labor market literature and trade literature thus propose two sources of pressure on the labor share of medium-skilled workers. My results indicate that for Western European countries the threat of substitution through ICT is *not* the driving force of the observed polarization. It is rather the threat to offshore production processes, which employ tasks that tend to be performed by medium-skilled and thus substitute local labor with foreign labor, that may cause the polarization.

Michael Spence recently wrote an article on “The Impact of Globalization on Income and Employment” in the US (Spence, 2011). He focuses on the substantial impact of economic integration in tradeable sectors which affects the whole working population in the US and has distributive implications. He urges policy makers in the US to address this issue which will remain after the current economic crises recede. The same applies to Western European policy makers as increasing globalization affects the distribution of income between capital and labor. As I show, wages in Europe will become more similar and workers in high-wage countries are confronted with lower wages or less employment if work is substitutable across countries. This paper shows a negative impact of economic integration on the labor share, but it cannot identify the specific causes. It will be necessary to investigate on a micro-level how much the negative impact originates from improvements of the outside option of the firms and how much other factors, such as decreases in competition and higher monopoly rents, cause this dynamic. Each cause will demand a different action in order to ensure sustainable incomes and employment in Western European countries for all workers.

5 Some Puzzling Trends in Key Economic Variables - A New-Institutional Approach

Abstract. This paper assesses empirically the hypotheses by Bental and Demougin (2010) that innovations in ICT (Information and Communication Technology) reduce the labor share in OECD countries by improving the monitoring technology. In a first step, I show that data trends for the labor share, wages in efficiency units, and labor in efficiency units over capital can be matched by a simulation of the model of Bental and Demougin (2010). In a second approach, I confirm increasing monitoring of workers using micro data for Germany. I argue that ICT influences labor not only through substitutability of labor with ICT and foreign work, but also through to lowering rents of workers as monitoring technology improves.

5.1 Introduction

Since the 1980s the income share of labor has decreased in many OECD countries. A common hypothesis for this decrease is capital augmenting technical change. Technological change, especially due to innovations in information and communication technology (ICT), is often assumed to be labor saving at least for specific skill groups. The labor saving aspect originates from a substitutability of ICT with labor. Bental and Demougin (2010) propose another channel through which ICT affects the labor share. In their model, ICT innovations enable more efficient monitoring of workers. With higher monitoring precision, the workers' rents can be reduced at every level of effort, which consequently lowers the labor share. The aim of this paper is to assess the model and the resulting hypotheses of Bental and Demougin (2010) against real world data.

Bental and Demougin (2010) explain the decreasing labor share by an institutional model where the downward movements the labor share, wages relative to productivity and effective labor relative to capital, are caused by an improvement in monitoring technology. The model is a partial equilibrium where a representative worker and a firm bargain over wage contracts. Since the worker's effort is not contractible, the firm offers him an incentive contract. The worker exerts more effort if he has a higher bargaining power and therefore receives a higher share of the profits. If the worker can be monitored, the need for incentives to induce effort is reduced. Consequently, as monitoring tightens, a given effort level can be achieved by lower bargaining power. Before bargaining takes place the firm has to invest into capital, which is the other input into production. As capital investments are made before wage bargaining, the firm faces a problem of irreversible investment. With a higher bargaining power for the firm, investment decisions are more efficient. If the bargaining power of the worker is reduced due to increased monitoring, the investment problem becomes less severe as the firm receives a higher share of the quasi-rents.

Bental and Demougin (2010) argue that the monitoring technology has steadily improved since 1980. It therefore takes less and less bargaining power to induce effort. The lower bargaining power relaxes the hold-up problem and investment into capital becomes more profitable. As a result, the labor share as well as wages decrease relative to productivity. As capital investments are more efficient, more capital is used in production relative to effective labor.

The falling labor share phenomenon is well known and has encouraged much research. Bentolia and Saint-Paul (2003), the European Commission (2007), and Checchi and Garcia-Penalosa (2010) find changes in labor market institutions, such as bargaining coordination, minimum wages, or unemployment benefits, to be influencing the labor share. Another set of studies focuses on the impact of globalization on the labor share. Harrison (2002), Guscina (2007), Jaumotte and Tytell (2008), and Jayadev (2007) show for different indicators for economic openness, that higher economic integration lowers the labor share in developed countries. Arpaia et al. (2009) argue that capital-augementing technological progress which is low-skilled labor saving, is a main force in reducing the labor share in Europe. The European Commission (2007) confirms a substitutability of low-skilled labor and capital, but find an overall positive correlation between labor and capital, similar to Checchi and Garcia-Penalosa (2010). The European Commission (2007) include ICT use in their analysis. Low-skilled work seems also substitutable to ICT, while the overall impact on the is insignificant. Schneider (2011) combines the analyses of economic integration and ICT innovations on the labor share. The study shows that there is a combined impact of ICT innovations and economic integration on the labor share.

Similar to the studies described above, the model by Bental and Demougin (2010) includes changes in labor market institutions and ICT innovations as causes for the decrease in the labor share. The causal relationship is nevertheless different. While bargaining power is exogenous in other studies, it is endogenous in the model by Bental and

Demougin (2010) and reacts to improvements in monitoring technology. Furthermore, ICT does not decrease wages, because the price of labor has to fall as its substitute, ICT, becomes cheaper, but because ICT reduces the information rents of the workers due to improvements in monitoring technology. I assess the hypotheses of Bental and Demougin (2010) empirically in two approaches. First, I simulate the model on a macro level for various countries. Then I analyze evidence of increasing monitoring intensity of workers on the micro level.

For the simulation of the model, I make two adjustments to the framework of Bental and Demougin (2010) it order to get a better fit to the data. First, I allow for a non-constant user cost of capital. Second, I analyze a suboptimal adjustment of the bargaining power, as I find this improves the results even more. Calibrating the model and simulating data for 1980 to 2000 shows that the adjusted model may explain the trends in the data.

For some countries, especially for France, the trends are well represented by the adjusted model, but the real-world data overshoots the predictions generated by a calibrated version of the model. To better match the levels, I assume, as a second adjustment to the Bental and Demougin (2010) approach, that the bargaining power is not distributed optimally, given the level of monitoring available. Specifically, in the case of France, assuming a biased bargaining process favoring labor generates results that are closer to the level of the real data. This seems likely as in the 1980s there was a labor favoring government under Mitterrand. For the US, the same exercise implies that there is a slight bias in favor of firms. For most other countries the optimal bargaining power implied by the model generates results that are consistent with the real-world data with respect to the trends as well as the level of the time series.

For the analysis of monitoring technology on the micro level, I use the German Socio-Economic Panel (SOEP) which has asked the participants how strongly they feel monitored on a three point scale. This question was asked in five waves between 1985 and 2001 and therefore covering almost the same time frame as the makro evaluation. The panel structure of the SOEP allows to distinguish between person specific effects and overall changes in the sample. I find that the overall average perceived monitoring intensity has increased between 1985 and 2001, while individuals feel less monitored over time. The individual effect can be explained by career advancement which lead to less monitored positions. These results are further hints on the reduction of wages due to improvements in the monitoring technology.

In the remainder of this paper, I will first present the model of Bental and Demougin (2010) with its main results in section two. In section three, I explain the calibration and discuss the results of the simulation. Section four shows the empirical assessment on the micro level and section five concludes.

5.2 The Model

Bental and Demougin (2010) consider a partial-equilibrium model with a principal-agent framework. A representative worker is employed by a representative firm. Both firm and worker are risk-neutral. The firm produces output with capital and labor employing a Cobb-Douglas technology. Specifically, the production function is of the form

$$F(e,k) = e^{\nu} k^{\gamma}, \qquad \nu, \gamma \in [0,1] \tag{5.1}$$

where e is the level of effort and k the level of capital per worker.

The worker's effort is not contractible. Therefore, he is paid via a bonus contract, which depends on a contractible binary signal $s \in \{0,1\}$. The probability of observing a positive signal, $s = 1$, increases in the effort of the worker. The better the signal reflects effort, the lower is the probability of obtaining a bonus for any effort of the worker. The firm is able to monitor the agent. It is assumed that an advanced monitoring technology is characterized by its ability to measure effort with a signal more precisely. Thus, given the effort of a worker, his bonus can be reduced with a higher monitoring precision.

The timing of the model is as follows. First the firm hires capital, then the worker and the firm are matched and bargain over quasi-rents. Bargaining is modeled as a generalized Nash Bargaining process, with bargaining power being determined by some institutional rules. Next, the worker chooses a level of effort, production takes place, and the signal is observed. Finally, wages are paid.

The problem is solved by backward induction. At the last stage, the worker decides upon his effort, given the bonus and the level of monitoring. The bonus is determined by the Nash-Bargaining Solution, assuming that the firms and workers have an outside option of zero. As the firm hires capital before bargaining, by the time of bargaining, the costs of capital are sunk. Thus, the firm faces a hold-up situation. Anticipating this, the firm's incentives to invest in capital are small, if the bargaining power of the workers is high, since the firm's share of the profit is small. On the other hand, under equal circumstances, higher incentives for the worker lead to higher effort. An optimally chosen bargaining power maximizes net output as a trade off between effort and capital inputs.

Bental and Demougin (2010) show that the labor share (LS), defined as expected bonus payments divided by total output, is

$$LS = (1-\alpha)\,\nu + \alpha, \qquad \alpha \in [0,1] \tag{5.2}$$

where α is the worker's bargaining power. As ν is bounded between zero and one, the labor share increases if α increases.

The capital-output ratio is

$$\frac{k}{y} = \frac{\gamma\,(1-\alpha)}{r}, \tag{5.3}$$

where r is the user cost of capital. It is equal to the interest rate, which Bental and Demougin (2010) assume to be constant, as the relative price of capital is normalized to unity.

In order to compare the model's results with real-world data Bental and Demougin (2010) translate the production function into a production function with a Harrod-neutral productivity factor. The resulting efficiency units, (E), can be written in terms of effort

$$E = e^{\frac{\nu}{1-\gamma}}. \tag{5.4}$$

Thus, the wage per efficiency unit, (W/E), is

$$\frac{W}{E} = [(1-\alpha)\,\nu + \alpha]\left(\frac{\gamma\,(1-\alpha)}{r}\right)^{\frac{\gamma}{1-\gamma}}. \tag{5.5}$$

Given equations 5.2 and 5.3, this can be written as,

$$\frac{W}{E} = LS\left(\frac{k}{y}\right)^{\frac{\gamma}{1-\gamma}}. \tag{5.6}$$

The last variable to be considered here is the ratio of labor in efficiency units to capital.

$$\frac{E}{k} = \left(\frac{\gamma\,(1-\alpha)}{r}\right)^{-\frac{1}{1-\gamma}} = \left(\frac{y}{k}\right)^{\frac{1}{1-\gamma}}. \tag{5.7}$$

Bental and Demougin (2010) assume that the bargaining power is set by a social planner who maximizes the sum of the worker's rent and the firm's profit. Consequently, the worker's bargaining power is a function of the monitoring technology. If the monitoring precision increases, the worker's bargaining power decreases and so does the labor share. Additionally, the capital-to-output ratio increases. Both capital and output increase due to a change in the monitoring technology. Holding γ and r constant, it is clear that capital increases faster than output since the bargaining power of the firm increases. Thus, an improved monitoring precision followed by a shift in bargaining power in favor of the firm, causes a decrease in real wages relative to efficiency units. Further, as capital increases faster than output, the labor in efficiency units per capital decreases.

In the following sections I first describe the observable data and then compare the real world-data to the simulated data.

5.3 Macroeconomic Assessment

5.3.1 Data Description

The data is taken from the OECD Economic Outlook and ranges from 1980 to 2000.[1] Labor shares were computed as total employment in the business sector times compensation per worker in the business sector divided by the nominal GDP of the business sector. It is therefore includes self-employed workers.

I calculate productivity following the standard assumption of a Cobb-Douglas production function with capital and effective labor.

$$Y_t = K_t^{\gamma} \left(A_t L_t\right)^{1-\gamma} \tag{5.8}$$

This leads to the following definition of efficiency units (productivity)

$$A_t = \left(\frac{Y_t}{K_t^{\gamma} L_t^{1-\gamma}}\right)^{\frac{1}{1-\gamma}}, \tag{5.9}$$

where A_t are the efficiency units in period t. Assuming now that the production technology is constant, γ is set to 0.3.

The time series of the OECD data are shown in figure 5.1. The top panel shows the labor shares, the middle panel shows the wages in efficiency units, and the bottom panel shows the amount of labor in efficiency units over capital.

The OECD-data, demonstrate that the labor share for France, Germany, the United States and the other countries of consideration has decreased over the last two and a half decades. In these countries, except for Japan and Spain, real wages relative to productivity have been decreasing as well in the same period, as can be seen in the second panel of figure 5.1. The neoclassical theory would now predict that as wages decrease, effective labor should increase relative to capital, as it becomes relatively cheaper. This

[1] I am grateful for being able to use the OECD data set from Bental and Demougin, who in turn received the data from Olivier Blanchard. See Blanchard (2006) and Bental and Demougin (2010).

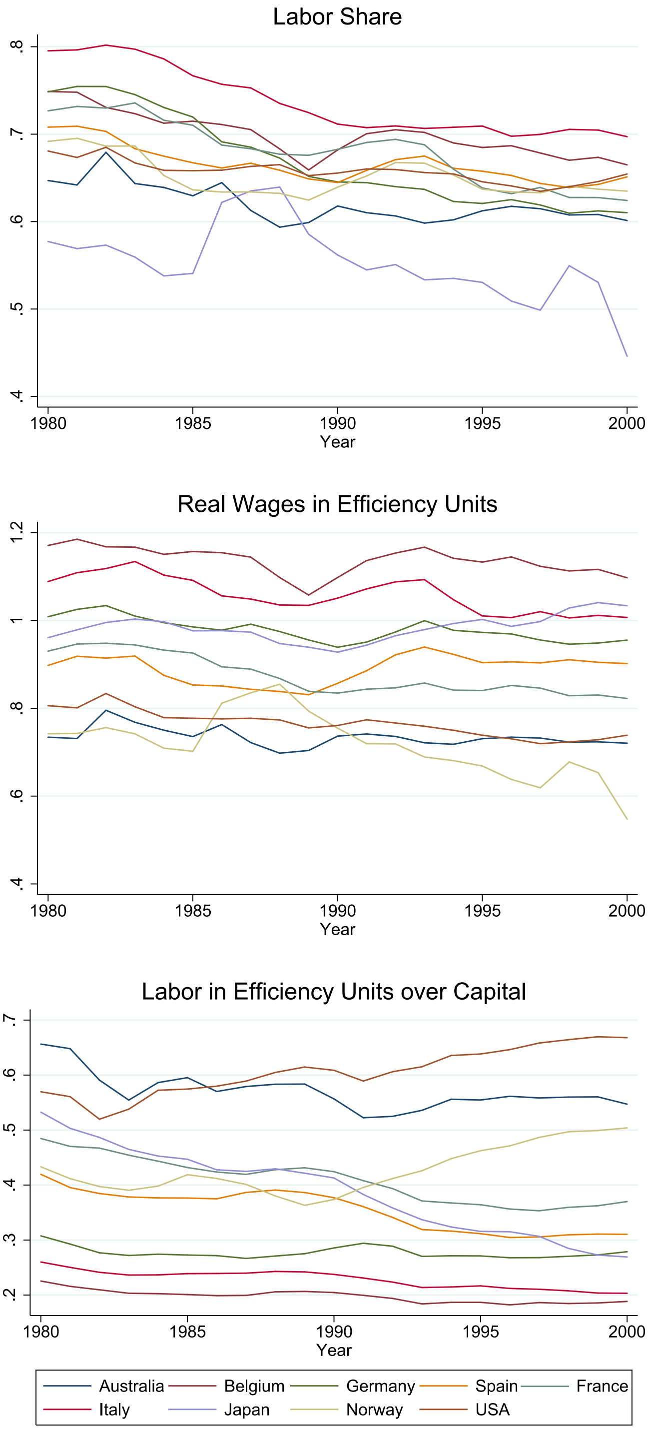

Figure 5.1: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital

is what has happened in the US and in Norway. There labor measured in efficiency units relative to capital has increased since 1980. This is shown in the third panels of figure 5.1. Analogously, effective labor relative to capital should decrease if wages relative to productivity increase. This is observable for Japan and Spain.

In France, Australia, Belgium, Italy, and Germany, the wages relative to productivity as well as the input of labor relative to capital decreased during the last two and a half decades. As mentioned above, this cannot be explained by the neoclassical approach. However it is consistent with the model by Bental and Demougin (2010). I show in the following section that with an extension of this model, not only the trends in France or Germany can be explained, but also the trends of the US, as well as Norwegian, Japanese or Spanish data.

5.3.2 Specifications of the Simulation

In order to show that the adjusted model can explain the trends I described before, I calibrate the model of Bental and Demougin (2010) and simulated the time frame from 1980 to 2000. In figures 4 to 12 the OECD-based data and the data from the simulated time series are presented within one figure, where the OECD data are represented by the black lines. These figures allow comparison of the real-world data to the simulated data with respect to trends and levels in order to decide whether the institutional approach leads to a suitable approximation.

In the simulation I calculate the optimal bargaining power, α, which is a function of the monitoring technology or precession, θ, the user cost of capital, r, the production function parameters, ν and γ and the cost of effort of the worker, c. Contrary to Bental and Demougin (2010), I assume that the user cost of capital is not constant over time. In order to determine the user cost from the model I use the labor shares equation (5.2) to compute a preliminary α[2]. Choosing an appropriate ν and using the OECD data, I compute for each year the resulting bargaining power of the worker.[3] Taking equation (5.3), the capital output ratio, it is then possible to find the user cost as $\frac{K_t}{Y_t}$ is also known from OECD-data. I compute the user cost of capital from

$$r_t = \gamma (1 - \alpha_t) \frac{Y_t}{K_t}. \tag{5.10}$$

[2]There is a tension between the "empirical" α_t generated by equation (5.2), and the optimal one. Another approach is to simultaneously generate the optimal α_t and r_t, and then use the results to compute labor shares. The latter should be compared to the data. Unfortunately, this is computationally much more cumbersome within the simulation.

[3]I used a simple linear approximation of the labor shares between 1980 and 2000. This simplifies the calculation in the simulation program.

Parameter	Description	Values
α	worker's bargaining power	endogenous, $[0, 1]$
θ	monitoring precision	linearly increasing $[0.25, 0.75]$
ν	Cobb-Douglas parameter[4]	country specific, see table 5.2
γ	Cobb-Douglas parameter, capital	0.3
r	user costs of capital	country specific, see table 5.2
c	costs of effort	1.1

Table 5.1: Calibration of Parameters

Country	values for ν	resulting values for r_t
France	0.6	0.066 - 0.086
Australia	0.45	0.134 - 0.143
Belgium	0.5	0.055 - 0.06
Italy	0.5	0.061 - 0.074
Germany	0.5	0.077 - 0.087
USA	0.6	0.165 - 0.2
Norway	0.4	0.1 - 0.15
Japan	0.6	0.1 - 0.09
Spain	0.5	0.11 - 0.098

Table 5.2: Choice of ν and r_t for calibration

With this approximate r_t, which varies across countries and the assumption of an increasing monitoring precision, I calculate the worker's optimal bargaining power. The bargaining power maximizes a social welfare function which equals the sum of the worker's and the firm's rent. The parameters and their values are given in table 5.1 and 5.2.

The user costs are determined by the movement of the labor share of the OECD data. The movement of the bargaining power depends also on the increasing monitoring precision. I calculated the optimal bargaining power for 20 periods, given the movement in the user costs between 1980 and 2000 and assuming an increase in the monitoring precision from 0.25 to 0.75 in these periods. With these parameters I simulate the labor share, equation (5.2), the wages per efficiency unit, equation (5.5), and the effective labor input relative to capital, equation (5.7). The resulting time series are shown as blue lines in figures 4 to 12.

5.3.3 Simulation Results

Optimal Bargaining Power

As it can be seen in figures 4 to 12, the trends of the time series can be reproduced with the simulation. Moreover the trends of data of the US, Norway, Japan and Spain, which do not follow the Neoclassical prediction, can be explained by this approach.

The graphs for Australia, Italy, Germany, Belgium, and France correspond to the predictions by Bental and Demougin (2010). As the moral-hazard problem weakens due to the increase in monitoring precision, the wages relative to productivity decrease. Since the hold-up problem slackens as well, firms invest more and productive labor relative to capital declines. At the same time the labor share decreases.

Interestingly, when assuming that the user cost of capital is not fixed over time, but adjusts in the model, the data of the US, Spain, Japan, and Norway are also explainable within the institutional setup. For the US data and the Norwegian data the wages relative to productivity decrease and effective labor relative to capital increases. For Japanese and Spanish data the model suggests, that the capital-output ratio increases faster than the labor share decreases. Therefore, wages relative to productivity increase and productive labor relative to capital decreases.

Biased Adjustment of Bargaining Power

Figure 4 shows a gap between the OECD and the simulated data if the bargaining power is adjusted optimally each period. Reasons for this gap can be found in the political process and the implementation of the institutions. The social planner does not necessarily give the same weight to the rents capital owners and workers when maximizing social welfare. Thus, I simulated the model for France assuming that the bargaining power of labor is biased towards labor. The dashed and dotted lines in figure 13 show cases where the bargaining power is determined by a welfare function that poses a higher valuation on the side of labor. I calculated the labor share, wages per efficiency unit, and the effective labor input relative to capital using the user cost of capital as in the optimal case, but with the following welfare function.

$$max_\alpha \, W = \pi \, (\text{worker's rent}) + (1 - \pi) \, (\text{firm's rent}) \tag{5.11}$$

π represents the weight of the interest group (workers and firms) in the social welfare function. The egalitarian rule, $\pi = 0.5$, is described in the subsection above. The higher π is, the more important is the workers welfare for the social planner or the more favorable are the bargaining institutions for the worker. These time series are shown as dashed/dotted lines in the figures for France, figure 13. For the US, figure 14, it is assumed that there is a bias towards the rent of the firm, implying that π may be smaller than 0.5.

The graphs show that as the adjustment process becomes more biased the simulated results get closer to the data. Specifically, the simulation results suggest that the French institutions induce a bargaining power of the workers which may be higher than expected given current state of technology and user cost of capital. Under the same assumption, the results for the US in figure 14 may indicate that institutions give slightly less bargaining power to the workers than under an optimal determination of bargaining power, since the actual labor share is below the simulated optimal labor share.

Similar results occur under the assumption of a sluggish adjustment process. In this case the regulator imposes a bargaining power which was optimal, given the monitoring technology and user cost of capital, five or ten periods before. Here the more lags are included the closer is the simulated data to the observed data. Both approaches lead to a much better fit in the levels of the simulation for both the France and the US.

5.4 Microeconomic Assessment

While it is not possible to simply estimate the parameter model of Bental and Demougin (2010), due to unobservable variables such as effort, some statistics from micro dataset can already indicate the relevance of the model. Specifically, I use data from the German Socio-Economic Panel Study (SOEP) to analyze monitoring at the workplace. The SOEP is an annual representative longitudinal micro-database with information on social and economic outcomes for private households in Germany since 1984. In the years 1985, 1987, 1989, 1995, and 2001 the SOEP asked the questions: *"Is your work strictly monitored?"*. The participant had three answers to choose from: *"Completely"* (3), *"Partly"* (2), *"Not At All"* (1). I use the information of this question as an indicator for the monitoring intensity at work, which is on a scale between one and three, where three is the highest level of monitoring intensity.

Table 5.3 shows some descriptive statistics for the sample. The sample contains only non-unemployed workers who are in the labor force. For the five years 18,748 observations are available and monitoring intensity has a mean of 1.66.

Splitting the sample into occupational positions shows that on average apprentices are monitored more closely than other occupational groups, while self-employed workers are least monitored. Monitoring is on average more intense in Manufacturing than in

Table 5.3: Perceived Monitoring Intensity, Descriptive Statistics

	N	Mean	Std. Dev.
Overall	18,748	1.66	0.722
by Occupational Position			
Apprentice	993	2.12	0.733
Self-Employed	1,509	1.21	0.511
Manual Laborer	7,514	1.84	0.750
Employee	7,399	1.51	0.644
Civil Servant	1,333	1.64	0.674
by Sector			
Manufacturing	3145	1.79	0.760
Service	5151	1.60	0.691
by Year			
1985	3,004	1.64	0.736
1987	3,306	1.65	0.737
1989	3,518	1.67	0.733
1995	4,567	1.65	0.707
2001	4,353	1.70	0.706

the service sector. On an two digit level, industries with a relatively high monitoring intensity and at least 10 observations are “Manufacturing of Vehicles” with a mean intensity of 1.96 (N=311) or “Sewage” with a mean intensity of 1.91 (N=22). Low mean monitoring intensities can be found for the industries “Renting of Machinery”, 1.2 (N=10), or “Research and Development”, 1.31 (N=16). On average the monitoring intensity increases over time.

In the model by Bental and Demougin (2010), increasing monitoring intensity is the driving force of the changes in the labor share. In order to analyze if there has been indeed a significant increase in monitoring intensity over time, I regress a time trend and later further controls on the indicator for monitoring. The results can be found in table 5.4. The time trend mirrors the distance of the time periods where the monitoring question is asked, such that the variable *Trend=1, 3, 5, 11, 17.* Column one shows the results for a regression with only an intercept and the trend. The coefficient on trend indicates a significant increase of the monitoring intensity over time in the pooled sample. Correcting for age and education[5] shows an even stronger positive trend. Including tenure and correcting for the occupational position leaves the coefficient unchanged.

Columns 4 to 7 show the repeated estimations including person fixed effect. The coefficients are therefore estimated on the differences of the mean value of the variable by person. If the time trend is regressed on the monitoring intensity with person fixed effects, the coefficient turns negative, indicating a decrease of the monitoring intensity over time. This is also indicated by the negative and significant coefficients on age and education. It can be expected that individuals are less intensely monitored if they are more experienced, have worked at the firm for a longer time, or are older and higher in the hierarchy. I therefore add controls for education, tenure, and occupational position. Adding all controls leaves the time trend insignificant and small.

The results from table 5.4 indicate that on average monitoring intensity increased for people with the same characteristics on age, education, and occupational positions. On an individual basis, monitoring intensity decreases throughout the working life, which can be explained by higher education and changes in job characteristics during the individual career.

[5]Education is clustered by highest degree into three groups: high (tertiary education), medium (vocational or general maturity certificate), low (no degree to intermediate general qualification).

Table 5.4: Changes of Monitoring Intensity over Time

	Dependent Variable: Monitoring Intensity						
	1	2	3	4	5	6	7
Trend	0.003***	0.007***	0.007***	0.007***	-0.004***	-0.003***	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Age		-0.008***	-0.009***	-0.005***			
		(0.000)	(0.001)	(0.001)			
Education		-0.142***	-0.142***	-0.043***		-0.125***	-0.049*
		(0.007)	(0.007)	(0.008)		(0.026)	(0.026)
Tenure			0.001	0.000			0.003**
			(0.001)	(0.001)			(0.002)
Occ.Position 2				-0.773***			-0.648***
				(0.029)			(0.049)
Occ.Position 3				-0.184***			-0.292***
				(0.026)			(0.038)
Occ.Position 4				-0.504***			-0.397***
				(0.026)			(0.038)
Occ.Position 5				-0.336***			-0.143*
				(0.033)			(0.076)
Constant	1.639***	2.149***	2.156***	2.222***	1.697***	1.878***	2.055***
	(0.009)	(0.021)	(0.022)	(0.028)	(0.008)	(0.038)	(0.045)
Fixed Effects					✓	✓	✓
N	18748	18748	18595	18595	18748	18748	18595
R^2	0.001	0.038	0.038	0.104	0.002	0.004	0.025

Robust standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Dummies for Occ.Position: (1) Apprentice, (2) Self-Employed, (3) Manual Laborer, (4) Employee, (5) Civil Servant.

Table 5.5: Monitoring Intensity and Wages

	Dependent Variable: Real Gross Monthly Wage				
	1	2	3	4	5
Monitoring	-127.966***	-67.345***	-49.249***	-17.778**	-2.428
	(9.441)	(10.302)	(9.303)	(8.654)	(13.288)
Education			300.778***	169.725***	278.408***
			(35.031)	(34.491)	(73.457)
Tenure			32.809***	30.075***	29.521***
			(3.221)	(3.203)	(4.529)
Tenure sqrt			-0.853***	-0.653***	-0.754***
			(0.092)	(0.092)	(0.137)
Fixed Effects		✓	✓	✓	✓
Year Dummies			✓	✓	✓
Occ.Position				✓	✓
Industry					✓
Constant	✓	✓	✓	✓	✓
N	18748	18748	18595	18595	9282
r2	0.009	0.003	0.128	0.169	0.230

Robust standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A further central hypothesis of Bental and Demougin (2010) is that rents and wages are reduced when the monitoring precision is increases. Table 5.5 shows the correlations of the monitoring intensity and real gross monthly wages. I regress the monitoring intensity and a constant on the real gross monthly wages and later include further controls which are common in Mincer type wage regressions (Mincer, 1974). In pooled OLS regression higher wages can be associated with lower monitoring intensity. Including person fixed effects and therefore controlling for all individual effects that do not change over the observed time, reduces the coefficient but leaves it negative and significant. Including education and tenure as a measure for experience as well as year dummies to account for macroeconomic factors reduces the correlation again, but it remains significant. The same happens when dummies for the occupational position are included. Controlling for industry on a two-digit level reduces the sample size by half and the coefficient of the monitoring intensity is small and insignificant. The decreasing coefficient of monitoring intensity as controls are included may be explained by the collinearity of monitoring with occupational and industry characteristics. As the monitoring intensity will be higher in some occupations and industries than it others, the correlation of monitoring will most likely be taken up in the industry and occupation indicators.

Furthermore, as mentioned above, the coefficients in the fixed effects regressions are identified only through changes from the individual mean. In order to see how many observations identify the coefficients on monitoring intensity, table 5.6 shows the amount

Table 5.6: Changes in the Monitoring Intensity

Δ Monitoring	Frequency	Percent
-2	407	3.52
-1	2,075	17.97
0	6,716	58.16
1	1,995	17.28
2	355	3.07
Total	11,548	100.00

Descriptive statistics for changes in the monitoring intensity between two consecutive observation periods by person.

of changes two subsequent periods in the monitoring variable. In 58 percent of cases the monitoring intensity reported by the subjects has not changed compared to the previous observation period. In about 36 percent of the cases the reported monitoring intensity moved by 1, in 6.5 percent by 2. In half of all changes a higher monitoring intensity than previously is reported and in the other half a lower. This also underlines the statement from above, that on an average individual level monitoring intensity did not increase over time, while the results from above show that the average monitoring intensity increased over time.

5.5 Conclusion

Bental and Demougin (2010) introduce a model which explains the downward trend of the labor share with an ICT induced improvement of monitoring precision which causes the rents of workers to fall. In this paper, I assess their hypotheses empirically. Their model is consistent with the downward trend of the labor share, wages relative to productivity, and effective labor relative to capital in France and other countries like Germany or Austria. I extend their model by allowing the user cost of capital to change over time. This leads to the conclusion that the model by Bental and Demougin (2010) is also consistent with the trends in macro economic US data as well as other countries like Norway, Spain, or Japan. Furthermore, analyzing German micro-panel data on the perceived monitoring intensity of workers, indicates that monitoring has indeed increased on average between 1985 and 2001.

The analysis of the impact of ICT on the labor share is closely connected to the analysis of the impact ICT on changes in the income distribution and on offshoring decisions. A recent strand of literature analyses how ICT influences the remuneration and relocation of specific tasks. Autor et al. (2003) introduce the idea that the production can be split into tasks which are routine and follow clear rules and tasks which non-routine. As the routine tasks can also be carried out by computers as clear rules are programmable, workers with routine tasks are substitutes to computers. The "Task"-literature explains decreasing wages and employment of workers with routine tasks, by the drop in prices of ICT. (Autor et al., 2003; Goos and Manning, 2007; Spitz-Oener, 2006; Acemoglu and Autor, 2011) Grossman and Rossi-Hansberg (2008) analyze the distributional effects that improvements in ICT have as specific tasks in the production process can be offshored more easily. Grossman and Rossi-Hansberg (2006) and Levy and Murnane (2004) underline that the routine tasks, which are more easily programmable, are also easier to offshore. Next to the fact that routine tasks are easier to explain to someone abroad they are also easier to monitor. Oldenski (2010) finds that firms relocate rather routine tasks through foreign direct investments while non-routine tasks are performed within the firm as communication is more important for these tasks.

It follows from the literature that routine tasks are more easily replaceable by a computer, they are easier to teach to workers abroad, they are more easily transferable abroad, and they are easier to monitor. While Grossman and Rossi-Hansberg (2006) and Levy and Murnane (2004) discuss the characteristic of routine tasks to be easier to monitor, they only mention improvements of monitoring possibilities through ICT over time in passing.

Schneider (2011) finds a common impact of ICT investments and economic integration as a main source for a decreasing labor share in European countries. The model by Bental and Demougin (2010) and my empirical assessment in this paper lead to an additional explanation of these trends. Not only the easier relocation of production processes through ICT, but also a reduction in rents through improvements in monitoring technology may be the cause. There may be two effects of improved monitoring technology on the labor share. In a direct effect, monitoring precision leads to a reduction in bargaining power and therefore in wages and in an indirect effect it improves the offshoring possibilities of firms as production process abroad can be more closely followed and assessed.

Future work should assess the impact of improving monitoring precision on wages for tasks in contrast to the price effect of decreasing prices on ICT. Furthermore the influence of ICT on bargaining power and their common impact on the labor share is interesting, but difficult to study. Common indicators for bargaining power are union coverage or strikes. These are very indirect measures as the bargaining power of a union may decrease while coverage is fixed. Stronger indicators for bargaining power would allow to disentangle different influences.

Appendix A: ICT and Skills

1 Descriptives and Test Statistics

Table 7: Compensation and Employment Shares by Skill Group on the Country Level

Compensation Share (upper row) and Employment Share (lower row) by Skill								
High-Skilled			Medium-Skilled			Low-Skilled		
1985	1995	2005	1985	1995	2005	1985	1995	2005
Australia								
11.5	22.4	30.2	40.6	36.9	37.8	47.9	40.8	32.0
7.1	14.6	19.6	36.1	34.7	39.1	56.8	50.7	41.3
Austria								
11.6	15.7	20.2	64.8	67.1	66.5	23.6	17.2	13.3
6.5	9.7	13.5	59.7	65.3	66.7	33.8	25.0	19.8
Czech Republic								
	22.5	27.8		71.6	68.5		5.9	3.7
	11.2	14.1		79.4	79.8		9.5	6.2
Denmark								
6.3	8.9	12.6	57.6	65.8	68.0	36.1	25.3	19.4
3.5	5.5	5.8	50.5	59.9	60.4	46.0	34.7	33.8
Finland								
31.6	41.9	46.6	32.2	35.4	38.9	36.2	22.6	14.5
21.6	32.0	35.0	37.2	41.1	45.9	41.2	26.9	19.1
Germany								
	15.3	18.3		68.0	63.7		16.7	18.0
	8.3	9.5		64.9	62.1		26.8	28.5
Italy								
6.6	9.5	17.9	89.8	89.5	81.8	3.6	1.0	0.2
5.8	7.8	12.8	89.0	89.6	86.1	5.2	2.7	1.2
Japan								
23.4	29.2	37.2	53.3	58.2	57.0	23.3	12.6	5.8
15.0	19.1	26.3	56.6	65.0	66.0	28.4	16.0	7.7
Korea								
37.1	42.6	58.6	38.4	40.6	34.7	24.5	16.9	6.7
21.3	30.6	47.3	43.2	47.3	43.1	35.4	22.1	9.6
Netherlands								
9.2	12.6	20.1	80.7	81.6	76.5	10.1	5.8	3.5
5.2	8.1	12.9	82.0	83.7	81.8	12.8	8.1	5.3
Slovenia								
	26.2	35.5		55.1	53.0		18.6	11.5
	13.4	20.5		60.1	62.2		26.5	17.3
Sweden								
15.8	17.9	26.8	61.7	62.0	60.7	22.5	20.0	12.5
10.6	12.1	19.9	63.3	64.8	64.6	26.2	23.1	15.4
UK								
14.8	22.0	27.9	62.7	66.2	64.6	22.5	11.8	7.6
8.0	12.7	18.9	62.7	68.5	68.8	29.3	18.8	12.3
US								
34.2	41.1	48.1	54.8	52.5	47.0	11.1	6.4	4.9
23.6	27.3	31.7	61.4	61.9	58.5	15.0	10.8	9.9

Table 8: 10 Year Average Annual Growth Rate of the Average Compensation Share and Employment Share by Skill Group on the Country Level

Average Annual Growth Rate of the Total Compensation Share (upper row) and Employment Share (lower row) by Country								
High-Skilled			Medium-Skilled			Low-Skilled		
75-85	85-95	95-05	75-85	85-95	95-05	75-85	85-95	95-05
Australia								
	0.067	0.030		-0.010	0.003		-0.016	-0.024
	0.073	0.029		-0.004	0.012		-0.012	-0.020
Austria								
	0.030	0.025		0.003	-0.001		-0.031	-0.026
	0.039	0.034		0.009	0.002		-0.030	-0.024
Czech Republic								
		0.021			-0.004			-0.047
		0.023			0.001			-0.043
Denmark								
	0.035	0.035		0.013	0.003		-0.035	-0.027
	0.050	0.036		0.018	0.006		-0.031	-0.020
Finland								
0.021	0.028	0.011	0.033	0.009	0.009	-0.035	-0.047	-0.044
0.040	0.039	0.009	0.041	0.010	0.011	-0.039	-0.043	-0.034
Germany								
		0.018			-0.006			0.007
		0.013			-0.004			0.006
Italy								
0.019	0.036	0.064	0.002	0.000	-0.009	-0.057	-0.126	-0.159
0.033	0.030	0.050	0.003	0.001	-0.004	-0.062	-0.067	-0.082
Japan								
0.028	0.022	0.024	0.012	0.009	-0.002	-0.041	-0.061	-0.077
0.038	0.024	0.032	0.018	0.014	0.002	-0.040	-0.058	-0.073
Korea								
0.001	0.014	0.032	0.019	0.005	-0.016	-0.026	-0.037	-0.093
0.013	0.036	0.043	0.032	0.009	-0.009	-0.034	-0.047	-0.084
Netherlands								
	0.032	0.047		0.001	-0.006		-0.055	-0.051
	0.046	0.046		0.002	-0.002		-0.046	-0.043
Slovenia								
		0.030			-0.004			-0.048
		0.042			0.003			-0.043
Sweden								
	0.012	0.040		0.001	-0.002		-0.012	-0.047
	0.014	0.050		0.002	0.000		-0.013	-0.040
UK								
0.087	0.039	0.024	0.023	0.005	-0.002	-0.067	-0.064	-0.045
0.094	0.047	0.039	0.027	0.009	0.000	-0.051	-0.045	-0.042
US								
0.031	0.018	0.016	0.001	-0.004	-0.011	-0.063	-0.055	-0.027
0.032	0.014	0.015	0.007	0.001	-0.006	-0.054	-0.033	-0.009

Table 9: Average Compensation Share and Employment Share by Skill Group and Industry

Average Compensation Share (upper row) and Employment Share (lower row) by Industry Across Countries

High-Skilled			Medium-Skilled			Low-Skilled		
1985	1995	2005	1985	1995	2005	1985	1995	2005
Mining and Quarrying								
11.9	16.8	20.2	56.1	59.9	64.3	31.9	23.4	15.5
8.1	11.8	14.3	55.1	61.1	66.5	36.8	27.1	19.2
Food, Beverages and Tobacco								
11.6	15.7	20.2	64.8	67.1	66.5	23.6	17.2	13.3
5.0	7.7	11.3	54.6	61.2	65.5	40.4	31.1	23.2
Textiles, Textile, Leather and Footwear								
6.8	10.4	17.0	55.1	61.6	64.8	38.1	28.0	18.3
3.8	6.3	10.6	52.9	60.3	65.7	43.4	33.4	23.7
Wood and of Wood and Cork								
9.4	12.7	18.6	55.9	63.2	64.8	34.7	24.1	16.6
5.9	8.9	13.0	54.7	62.8	66.0	39.5	28.3	20.9
Pulp, Paper, Printing and Publishing								
12.9	17.7	23.1	60.0	63.8	64.4	27.2	18.5	12.5
8.6	13.1	17.4	58.9	63.9	66.2	32.5	23.0	16.5
Coke, Refined Petroleum and Nuclear Fuel								
15.0	19.1	24.7	60.3	63.6	63.6	24.7	17.3	11.7
10.3	14.2	18.0	60.7	64.9	66.7	29.0	20.9	15.3
Chemicals and Chemical								
16.8	22.3	29.2	57.4	59.8	59.3	25.8	17.9	11.5
11.3	16.7	21.9	57.8	61.4	63.0	30.9	21.9	15.1
Rubber and Plastics								
11.4	14.9	20.8	58.4	63.7	64.7	30.2	21.4	14.5
7.2	10.4	14.3	57.5	63.9	67.1	35.2	25.8	18.7
Other Non-Metallic Mineral								
10.2	13.0	19.1	56.0	62.8	64.6	33.8	24.2	16.3
6.6	9.1	13.3	55.2	62.9	66.5	38.2	28.0	20.2
Basic Metals and Fabricated Metal								
10.2	13.0	18.7	58.4	64.6	66.4	31.4	22.4	14.9
6.7	9.2	13.1	57.2	64.5	68.0	36.2	26.4	18.9
Machinery, Nec.								
12.3	16.5	24.3	63.6	66.4	64.5	24.1	17.2	11.2
8.3	11.7	17.3	62.8	67.4	68.1	28.9	20.9	14.7
Electrical and Optical Equipment								
14.7	19.9	27.9	62.1	63.6	61.3	23.2	16.5	10.8
9.8	14.0	20.1	61.9	65.6	65.5	28.3	20.5	14.4
Transport Equipment								
14.1	16.6	22.8	62.8	64.9	64.8	23.1	18.5	12.4
8.4	12.0	16.4	61.5	65.9	67.8	30.0	22.0	15.8

Continued on next page

Table 9 – *continued from previous page*

High-Skilled			Medium-Skilled			Low-Skilled		
1985	1995	2005	1985	1995	2005	1985	1995	2005
Manufacturing Nec.; Recycling								
12.1	13.8	19.8	57.5	62.5	64.6	30.4	23.8	15.5
6.6	9.6	13.5	55.8	62.2	66.3	37.6	28.2	20.2
Electricity, Gas and Water Supply								
16.5	20.8	25.5	63.6	66.1	65.2	20.0	13.1	9.2
12.5	16.7	20.4	63.8	67.4	67.6	23.7	15.9	12.0
Construction								
12.4	14.0	16.2	60.7	67.4	69.7	26.9	18.6	14.1
9.3	11.1	12.8	59.8	66.7	69.2	30.9	22.3	17.9
Wholesale and Retail Trade								
14.4	16.1	22.8	62.5	66.8	64.0	23.1	17.1	13.2
9.6	11.3	15.9	62.3	66.7	66.3	28.1	22.0	17.9
Hotels and Restaurants								
8.4	11.2	16.6	60.5	65.8	66.1	31.1	23.0	17.3
5.5	7.8	11.3	58.4	64.2	66.2	36.1	28.0	22.5
Transport and Storage								
7.5	10.2	14.3	60.2	66.2	67.7	32.3	23.7	18.0
5.5	7.8	10.8	58.7	65.7	68.1	35.8	26.5	21.1
Post and Telecommunications								
8.8	13.8	24.2	61.5	64.6	61.0	29.6	21.6	14.7
6.8	11.2	17.9	60.4	64.6	63.7	32.8	24.2	18.5
Financial Intermediation								
25.1	32.8	43.0	61.8	58.0	50.8	13.1	9.2	6.3
18.1	24.7	32.5	65.2	62.5	57.6	16.7	12.8	10.0
Real Estate, Renting and Business Activities								
30.1	38.1	47.6	53.7	50.3	44.5	16.2	11.6	7.9
22.0	28.2	36.2	55.7	54.8	51.1	22.3	17.0	12.7
Other Community, Social and Personal Services								
20.6	26.0	31.8	57.8	58.5	58.1	21.6	15.5	10.1
12.7	18.1	22.9	58.5	61.2	62.5	28.8	20.7	14.6

Compensation and employment shares are measured here as an average of each industry across the countries Australia, Austria, Denmark, Finland, Italy, Japan, Korea, Netherlands, United Kingdom, and United States.

Table 10: 10 Year Average Annual Growth Rate of the Average Compensation Share and Employment Share by Skill Group and Industry

Average Annual Growth Rate of the Average Total Compensation Share (upper row) and Employment Share (lower row) by Industry								
High-Skilled			Medium-Skilled			Low-Skilled		
75-85	85-95	95-05	75-85	85-95	95-05	75-85	85-95	95-05
Mining and Quarrying								
0.000	0.006	0.019	0.027	0.006	0.007	-0.034	-0.031	-0.041
0.009	0.037	0.019	0.022	0.010	0.008	-0.028	-0.031	-0.034
Food, Beverages and Tobacco								
-0.007	0.038	0.038	0.025	0.009	0.004	-0.030	-0.031	-0.037
0.005	0.044	0.039	0.027	0.011	0.007	-0.028	-0.026	-0.030
Textiles, Textile, Leather and Footwear								
-0.004	0.042	0.049	0.028	0.011	0.005	-0.030	-0.031	-0.043
0.012	0.051	0.052	0.030	0.013	0.009	-0.028	-0.026	-0.034
Wood and of Wood and Cork								
0.005	0.030	0.038	0.028	0.012	0.003	-0.034	-0.036	-0.038
0.016	0.042	0.038	0.024	0.014	0.005	-0.028	-0.033	-0.030
Pulp, Paper, Printing and Publishing								
-0.008	0.032	0.026	0.023	0.006	0.001	-0.035	-0.038	-0.039
-0.001	0.041	0.028	0.019	0.008	0.003	-0.027	-0.034	-0.033
Coke, Refined Petroleum and Nuclear Fuel								
-0.013	0.024	0.026	0.023	0.005	0.000	-0.035	-0.035	-0.039
-0.007	0.032	0.024	0.019	0.007	0.003	-0.030	-0.033	-0.031
Chemicals and Chemical								
-0.009	0.028	0.027	0.023	0.004	-0.001	-0.034	-0.036	-0.044
-0.004	0.039	0.027	0.019	0.006	0.003	-0.027	-0.034	-0.037
Rubber and Plastics								
-0.008	0.027	0.033	0.023	0.009	0.002	-0.031	-0.034	-0.039
0.004	0.036	0.032	0.020	0.010	0.005	-0.026	-0.031	-0.032
Other Non-Metallic Mineral								
0.003	0.024	0.039	0.024	0.011	0.003	-0.031	-0.033	-0.040
0.013	0.032	0.037	0.021	0.013	0.006	-0.026	-0.031	-0.033
Basic Metals and Fabricated Metal								
-0.002	0.024	0.037	0.024	0.010	0.003	-0.033	-0.034	-0.041
0.009	0.032	0.035	0.020	0.012	0.005	-0.026	-0.032	-0.033
Machinery, Nec.								
0.005	0.029	0.039	0.021	0.004	-0.003	-0.042	-0.034	-0.043
0.017	0.034	0.039	0.020	0.007	0.001	-0.037	-0.033	-0.035
Electrical and Optical Equipment								
0.002	0.031	0.034	0.019	0.002	-0.004	-0.039	-0.034	-0.042
0.012	0.036	0.036	0.018	0.006	0.000	-0.034	-0.032	-0.035
Transport Equipment								
0.016	0.016	0.032	0.023	0.003	0.000	-0.050	-0.022	-0.040
0.016	0.036	0.031	0.022	0.007	0.003	-0.037	-0.031	-0.033

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Table 10 – *continued from previous page*

High-Skilled			Medium-Skilled			Low-Skilled		
75-85	85-95	95-05	75-85	85-95	95-05	75-85	85-95	95-05
Manufacturing Nec.; Recycling								
0.017	0.013	0.037	0.026	0.008	0.003	-0.041	-0.025	-0.043
0.012	0.037	0.035	0.025	0.011	0.006	-0.030	-0.029	-0.033
Electricity, Gas and Water Supply								
-0.008	0.023	0.021	0.012	0.004	-0.001	-0.027	-0.042	-0.035
-0.002	0.029	0.020	0.009	0.005	0.000	-0.020	-0.040	-0.028
Construction								
-0.013	0.012	0.014	0.015	0.010	0.003	-0.023	-0.037	-0.028
-0.007	0.018	0.015	0.013	0.011	0.004	-0.019	-0.033	-0.022
Wholesale and Retail Trade								
-0.015	0.011	0.035	0.014	0.007	-0.004	-0.024	-0.030	-0.026
-0.004	0.016	0.034	0.010	0.007	-0.001	-0.019	-0.024	-0.021
Hotels and Restaurants								
-0.001	0.029	0.039	0.020	0.008	0.001	-0.030	-0.030	-0.029
0.010	0.035	0.037	0.018	0.009	0.003	-0.024	-0.025	-0.022
Transport and Storage								
0.000	0.030	0.034	0.015	0.010	0.002	-0.023	-0.031	-0.027
0.009	0.034	0.033	0.014	0.011	0.004	-0.021	-0.030	-0.023
Post and Telecommunications								
0.003	0.045	0.056	0.007	0.005	-0.006	-0.013	-0.032	-0.038
0.008	0.049	0.047	0.002	0.007	-0.001	-0.006	-0.030	-0.027
Financial Intermediation								
-0.006	0.027	0.027	0.003	-0.006	-0.013	-0.004	-0.035	-0.038
-0.001	0.031	0.027	0.000	-0.004	-0.008	0.000	-0.027	-0.025
Real Estate, Renting and Business Activities								
-0.005	0.024	0.022	0.007	-0.007	-0.012	-0.013	-0.034	-0.038
-0.003	0.025	0.025	0.007	-0.002	-0.007	-0.013	-0.027	-0.029
Other Community, Social and Personal Services								
0.006	0.023	0.020	0.016	0.001	-0.001	-0.037	-0.033	-0.042
0.006	0.036	0.023	0.018	0.005	0.002	-0.030	-0.033	-0.035

Compensation and employment shares are measured here as an average of each industry across the countries Australia, Austria, Denmark, Finland, Italy, Japan, Korea, Netherlands, United Kingdom, and United States.

Table 11: Share of ICT Investment in Value Added in Levels and the 10 Year Average Annual Growth Rate

$\frac{K^{ICT}}{Y}$ in levels			$\frac{K^{ICT}}{Y}$ growth rate		
1985	1995	2005	75-85	85-95	95-05
Australia					
0.010	0.030	0.195	0.066	0.105	0.188
Austria					
0.009	0.019	0.076		0.077	0.137
Czech Republic					
	0.031	0.103			0.119
Denmark					
0.011	0.033	0.181	0.234	0.114	0.170
Finland					
0.012	0.029	0.060	0.070	0.093	0.071
Germany					
	0.021	0.064			0.112
Italy					
0.011	0.020	0.050	0.071	0.064	0.091
Japan					
0.015	0.028	0.059	0.135	0.062	0.073
Korea					
0.012	0.030	0.071		0.090	0.086
Netherlands					
0.012	0.027	0.104	0.084	0.080	0.133
Slovenia					
	0.026	0.077			0.110
Sweden					
	0.035	0.057			0.048
UK					
0.013	0.035	0.127	0.078	0.100	0.128
US					
0.002	0.010	0.068	0.389	0.171	0.195

Table 12: Average Share of ICT Investment in Value Added in Levels and the 10 Year Average Annual Growth Rate.

$\frac{K^{ICT}}{Y}$ in levels			$\frac{K^{ICT}}{Y}$ growth rate		
1985	1995	2005	75-85	85-95	95-05
Mining and Quarrying					
0.006	0.013	0.057	0.140	0.072	0.149
Food, Beverages and Tobacco					
0.006	0.016	0.074	0.081	0.104	0.152
Textiles, Textile, Leather and Footwear					
0.003	0.011	0.065	0.126	0.132	0.174
Wood and of Wood and Cork					
0.005	0.009	0.042	-0.005	0.055	0.155
Pulp, Paper, Printing and Publishing					
0.008	0.026	0.126	0.114	0.118	0.160
Coke, Refined Petroleum and Nuclear Fuel					
0.032	0.128	0.124	0.174	0.140	0.169
Chemicals and Chemical					
0.011	0.019	0.056	-0.027	0.060	0.106
Rubber and Plastics					
0.007	0.013	0.049	0.141	0.068	0.131
Other Non-Metallic Mineral					
0.005	0.012	0.067	0.145	0.086	0.171
Basic Metals and Fabricated Metal					
0.006	0.014	0.043	0.067	0.078	0.112
Machinery, Nec.					
0.010	0.021	0.079	0.118	0.068	0.135
Electrical and Optical Equipment					
0.027	0.037	0.079	0.079	0.032	0.075
Transport Equipment					
0.010	0.021	0.067	0.134	0.073	0.115
Manufacturing Nec.; Recycling					
0.005	0.015	0.071	0.108	0.101	0.156
Electricity, Gas and Water Supply					
0.012	0.021	0.089	0.036	0.058	0.143

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Table 12 – *continued from previous page*

$\frac{K^{ICT}}{Y}$ in levels			$\frac{K^{ICT}}{Y}$ growth rate		
1985	1995	2005	75-85	85-95	95-05
Construction					
0.002	0.009	0.030	0.100	0.124	0.125
Wholesale and Retail Trade					
0.011	0.022	0.088	0.102	0.072	0.139
Hotels and Restaurants					
0.005	0.012	0.043	0.157	0.085	0.126
Transport and Storage					
0.017	0.032	0.090	0.038	0.061	0.104
Post and Telecommunications					
0.132	0.161	0.156	0.109	0.020	-0.003
Financial Intermediation					
0.020	0.057	0.200	0.092	0.103	0.126
Real Estate, Renting and Business Activities					
0.010	0.030	0.138	0.116	0.115	0.151
Other Community, Social and Personal Services					
0.013	0.033	0.138	0.158	0.093	0.142

$\frac{ICT}{Y}$ is measured here as an average of each industry across the countries Australia, Austria, Denmark, Finland, Italy, Japan, Korea, Netherlands, United Kingdom, and United States.

2 Estimation Results - Structural Break

Table 13: Test of the Constant Returns to Scale in Production by Country

F-Statistic for	Test of Regression by Skill Group		
	High	Medium	Low
Australia	0.32	2.51	0.00
Austria	5.30	11.56	5.45
Czech Republic	0.54	0.49	0.63
Denmark	0.65	0.64	2.66
Finland	0.07	1.08	1.01
Germany	0.02	6.61	3.21
Italy	1.16	0.09	4.26
Japan	1.89	0.62	0.24
Korea	1.95	0.38	1.30
Netherlands	5.27	8.81	9.36
Slovenia	0.92	11.45	1.21
Sweden	3.58	8.42	4.52
United Kingdom	3.98	5.99	5.65
United States	45.70	129.68	95.23

Test of the H0: $\beta_Y + \beta_K + \beta_{K^{ICT}} = 0$.

Table 14: Test of the Constant Returns to Scale in Production by Industry.

F-Statistic for	Test of Regression by Skill Group		
	High	Medium	Low
Mining and Quarrying	0.52	2.96	1.75
Food, Beverages and Tobacco	1.20	2.00	0.70
Textiles, Textile, Leather and Footwear	0.02	2.83	1.58
Wood and of Wood and Cork	0.08	7.18	2.38
Chemicals and chemical	0.17	1.23	0.53
Pulp, Paper, Printing and Publishing	0.35	1.62	1.11
Coke, refined petroleum and nuclear fuel	0.37	0.58	0.37
Rubber and plastics	0.05	1.25	0.75
Other Non-Metallic Mineral	0.00	0.52	0.20
Basic Metals and Fabricated Metal	1.76	2.11	2.03
Machinery, Nec.	0.04	0.37	0.35
Electrical and Optical Equipment	0.46	0.01	0.15
Transport Equipment	13.36	0.22	3.98
Manufacturing Nec.; Recycling	1.78	0.07	1.36
Electricity, Gas and Water Supply	0.51	1.11	2.24
Construction	0.01	25.04	17.37
Wholesale and Retail Trade	0.20	10.25	5.82
Hotels and Restaurants	4.13	1.42	0.48
Transport and Storage	0.93	6.96	1.09
Post and Telecommunications	0.63	3.78	6.88
Financial Intermediation	0.55	6.48	0.38
Real Estate, Renting and Business Activities	0.00	0.02	0.05
Other Community, Social and Personal Services	3.51	0.24	4.96

Test of the H0: $\beta_Y + \beta_K + \beta_{K^{ICT}} = 0$.

Table 15: Structural Break Regressions by Country

Regression by time period: 1970 to 1994 and before and 1995 to 2005						
	Dependent Variable: Relative Compensation Share of the Respective Skill Group					
Industry	High-Skilled		Medium-Skilled		Low-Skilled	
Variable	until 1994	1995-2005	until 1994	1995-2005	until 1994	1995-2005
Australia						
$ln\frac{K^{ICT}}{Y}$	4.855**	2.702	0.334	-0.171	-5.190**	-2.531
	(2.032)	(2.270)	(0.798)	(0.495)	(2.437)	(2.054)
$ln\frac{K}{Y}$	*-10.61**	*-7.432*	-3.636	-4.029	*14.24*	*11.46*
	(6.166)	(6.125)	(2.995)	(2.979)	(8.329)	(8.324)
N	552		552		552	
R^2	0.978		0.999		0.995	
Austria						
$ln\frac{K^{ICT}}{Y}$	*-0.055*	*1.574*	*-1.349*	*-3.863****	1.404	2.289**
	(1.110)	(1.451)	(1.365)	(1.311)	(1.390)	(1.089)
$ln\frac{K}{Y}$	1.680	3.406	*-2.944*	*-5.049*	1.264	1.643
	(2.663)	(2.951)	(3.390)	(3.201)	(1.985)	(2.111)
N	598		598		598	
R^2	0.977		0.999		0.994	
Denmark						
$ln\frac{K^{ICT}}{Y}$	*0.317*	*1.909***	*1.373*	*-5.221****	*-1.690*	*3.313****
	(0.566)	(0.708)	(2.250)	(1.615)	(1.816)	(1.053)
$ln\frac{K}{Y}$	*-4.253****	*-3.368***	5.316**	4.238	-1.063	-0.870
	(1.053)	(1.282)	(2.263)	(2.793)	(1.556)	(1.809)
N	598		598		598	
R^2	0.989		0.998		0.995	

Continued on next page

Table 15 – *continued from previous page*

Dependent Variable: Relative Compensation Share of the Respective Skill Group						
Industry	High-Skilled		Medium-Skilled		Low-Skilled	
Variable	until 1994	1995-2005	until 1994	1995-2005	until 1994	1995-2005
Finland						
$ln\frac{K^{ICT}}{Y}$	-1.188***	2.025*	2.344***	-1.145	-1.156*	-0.880
	(0.368)	(1.011)	(0.762)	(2.216)	(0.620)	(1.646)
$ln\frac{K}{Y}$	-1.207	-2.155	-0.996	-1.529	2.204	3.684
	(1.913)	(1.640)	(3.517)	(4.170)	(2.662)	(3.387)
N	797		797		797	
R^2	0.996		0.993		0.997	
Italy						
$ln\frac{K^{ICT}}{Y}$	1.487	0.694	-2.433**	-3.279***	0.946*	2.585**
	(1.176)	(1.264)	(1.095)	(1.022)	(0.530)	(1.070)
$ln\frac{K}{Y}$	-6.659*	-2.049	9.383**	4.840	-2.723*	-2.791
	(3.708)	(2.539)	(3.480)	(2.910)	(1.462)	(1.647)
N	828		828		828	
R^2	0.877		0.999		0.909	
Japan						
$ln\frac{K^{ICT}}{Y}$	1.614	4.851**	-1.972	-9.573***	0.357	4.722**
	(0.952)	(1.795)	(2.142)	(3.356)	(1.427)	(1.886)
$ln\frac{K}{Y}$	-3.835**	-5.890**	6.767	11.92**	-2.932	-6.028*
	(1.564)	(2.104)	(4.586)	(5.270)	(3.204)	(3.467)
N	759		759		759	
R^2	0.995		0.995		0.986	
Korea						
$ln\frac{K^{ICT}}{Y}$	0.618	0.970	-2.283	-2.343*	1.666	1.372
	(0.873)	(0.712)	(1.342)	(1.345)	(1.717)	(1.647)
$ln\frac{K}{Y}$	-1.409	1.083	5.540**	6.166***	-4.131	-7.249***
	(1.598)	(1.661)	(2.377)	(1.736)	(3.494)	(2.208)
N	667		667		667	
R^2	0.992		0.992		0.971	

Continued on next page

Table 15 – *continued from previous page*

Dependent Variable: Relative Compensation Share of the Respective Skill Group						
Industry	High-Skilled		Medium-Skilled		Low-Skilled	
Variable	until 1994	1995-2005	until 1994	1995-2005	until 1994	1995-2005
Netherlands						
$ln\frac{K^{ICT}}{Y}$	*-1.007*	*0.954*	*-0.876*	*-4.025*	1.883**	3.071**
	(0.706)	(1.456)	(1.439)	(2.675)	(0.810)	(1.350)
$ln\frac{K}{Y}$	*2.364*	*3.908**	*0.566*	*-3.259*	*-2.930*	*-0.649*
	(1.935)	(2.126)	(4.381)	(4.251)	(3.006)	(2.968)
N	621		621		621	
R^2	0.985		0.999		0.974	
UK						
$ln\frac{K^{ICT}}{Y}$	-1.197	0.304	2.845	0.404	-1.648	-0.708
	(1.861)	(1.978)	(3.670)	(5.589)	(2.489)	(4.242)
$ln\frac{K}{Y}$	*1.314*	*4.239*	-1.819	-6.144	0.505	1.905
	(3.981)	(3.438)	(11.53)	(10.83)	(8.171)	(8.573)
N	828		828		828	
R^2	0.963		0.987		0.978	
USA						
$ln\frac{K^{ICT}}{Y}$	*-0.297*	*3.225***	*-0.297*	*-7.444****	*0.594*	*4.219****
	(0.689)	(1.257)	(1.335)	(1.783)	(0.732)	(1.106)
$ln\frac{K}{Y}$	*-2.680*	*-3.412*	3.696	4.228	-1.015	-0.816
	(2.197)	(2.608)	(4.155)	(4.404)	(2.227)	(2.335)
N	828		828		828	
R^2	0.995		0.995		0.978	

***,**,*: statistically significant at 1, 5, and 10 % level, respectively;
Fixed Effects estimation; Robust standard errors in parentheses;
Year dummies are included in each regression;
The regressions are weighted by average labor costs share of each industry.
Each regressor is interacted with a dummy indicating the period 1970 to 1994 and with one for the period 1995 to 2005.
Coefficients in italic indicate a significant difference between the coefficients of both time periods on the 10% level.

Table 16: Structural Break Regressions by Industry

Regression by time period: 1970 to 1994 and before and 1995 to 2005						
Dependent Variable: Relative Compensation Share of the Respective Skill Group						
Industry	High-Skilled		Medium-Skilled		Low-Skilled	
Variable	until 1994	1995-2005	until 1994	1995-2005	until 1994	1995-2005
Mining and Quarrying						
$ln\frac{K^{ICT}}{Y}$	-1.174	-1.089	0.0993	-2.050	1.075	3.139***
	(0.753)	(0.819)	(0.593)	(1.240)	(1.097)	(0.818)
$ln\frac{K}{Y}$	2.806	5.990	4.080	3.309	-6.886	-9.299
	(2.728)	(3.927)	(3.267)	(3.388)	(4.881)	(5.967)
N	304		304		304	
R^2	0.978		0.996		0.986	
Food, Beverages and Tobacco						
$ln\frac{K^{ICT}}{Y}$	0.013	1.183	-4.906**	-4.304	4.892**	3.121
	(1.049)	(0.998)	(2.044)	(2.716)	(1.736)	(3.171)
$ln\frac{K}{Y}$	*0.393*	*-9.614**	4.298	-1.658	-4.691*	11.27
	(2.100)	(3.584)	(3.443)	(10.26)	(2.541)	(11.56)
N	309		309		309	
R^2	0.978		0.995		0.985	
Textiles, Textile, Leather and Footwear						
$ln\frac{K^{ICT}}{Y}$	2.938**	1.711	2.847	4.064	-5.785	-5.775
	(1.118)	(1.499)	(2.949)	(3.948)	(3.580)	(4.746)
$ln\frac{K}{Y}$	*5.395***	*1.590*	0.643	3.881	-6.038	-5.471
	(2.280)	(2.512)	(4.987)	(7.980)	(6.020)	(8.749)
N	304		304		304	
R^2	0.968		0.994		0.974	

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Table 16 – *continued from previous page*

Dependent Variable: Relative Compensation Share of the Respective Skill Group						
Industry	High-Skilled		Medium-Skilled		Low-Skilled	
Variable	until 1994	1995-2005	until 1994	1995-2005	until 1994	1995-2005
Wood and of Wood and Cork						
$ln\frac{K^{ICT}}{Y}$	0.178	-0.185	1.440	0.899	-1.618	-0.714
	(0.703)	(1.943)	(1.275)	(2.871)	(1.941)	(3.608)
$ln\frac{K}{Y}$	1.446	-1.703	-0.468	-1.000	-0.978	2.703
	(2.191)	(4.122)	(6.216)	(8.476)	(6.120)	(9.944)
N	308		308		308	
R^2	0.983		0.996		0.981	
Pulp, Paper, Printing and Publishing						
$ln\frac{K^{ICT}}{Y}$	_1.782**_	_-0.044_	-3.247	0.901	1.465	-0.857
	(0.576)	(0.871)	(1.902)	(2.819)	(1.831)	(3.345)
$ln\frac{K}{Y}$	-0.651	-5.266	-3.335	-5.871	3.986	11.14
	(2.258)	(4.213)	(4.207)	(10.38)	(4.712)	(12.48)
N	309		309		309	
R^2	0.989		0.994		0.974	
Coke, Refined Petroleum and Nuclear Fuel						
$ln\frac{K^{ICT}}{Y}$	0.635	-0.530	-0.622	-0.306	-0.013	0.836
	(0.562)	(0.850)	(1.772)	(1.636)	(1.876)	(2.316)
$ln\frac{K}{Y}$	-1.782	-1.621	1.907	-0.445	-0.126	2.066
	(1.061)	(1.694)	(4.051)	(2.904)	(4.321)	(3.635)
N	304		304		304	
R^2	0.992		0.991		0.949	
Chemicals and Chemical						
$ln\frac{K^{ICT}}{Y}$	1.521**	2.639**	-3.919	2.359	2.398	-4.998
	(0.575)	(0.939)	(3.432)	(4.223)	(3.242)	(4.476)
$ln\frac{K}{Y}$	_-0.923_	_-7.947***_	6.899	-3.977	-5.976	11.92*
	(2.227)	(2.395)	(7.106)	(8.072)	(7.127)	(6.370)
N	309		309		309	
R^2	0.995		0.991		0.959	

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Table 16 – *continued from previous page*

Dependent Variable: Relative Compensation Share of the Respective Skill Group						
Industry	High-Skilled		Medium-Skilled		Low-Skilled	
Variable	until 1994	1995-2005	until 1994	1995-2005	until 1994	1995-2005
Rubber and Plastics						
$ln\frac{K^{ICT}}{Y}$	-0.573	0.467	-4.307**	-2.002	4.880**	1.535
	(0.773)	(1.573)	(1.496)	(2.313)	(1.767)	(3.472)
$ln\frac{K}{Y}$	-0.665	-7.111	10.98*	3.217	-10.31*	3.894
	(2.589)	(4.227)	(4.861)	(7.153)	(5.154)	(10.40)
N	302		302		302	
R^2	0.985		0.996		0.972	
Other Non-Metallic Mineral						
$ln\frac{K^{ICT}}{Y}$	-0.138	0.296	-0.779	-2.132	0.918	1.836
	(1.007)	(1.086)	(1.264)	(1.664)	(2.094)	(2.101)
$ln\frac{K}{Y}$	0.626	-4.412	11.81*	4.368	-12.43	0.0444
	(2.671)	(4.223)	(5.549)	(5.610)	(8.091)	(9.011)
N	308		308		308	
R^2	0.977		0.997		0.980	
Basic Metals and Fabricated Metal						
$ln\frac{K^{ICT}}{Y}$	-0.494	-0.292	-0.480	-0.685	0.974	0.978
	(0.736)	(1.993)	(2.131)	(2.894)	(2.696)	(4.244)
$ln\frac{K}{Y}$	-0.211	-5.629	2.981	-1.597	-2.769	7.227
	(2.884)	(4.808)	(8.028)	(9.757)	(10.59)	(14.25)
N	309		309		309	
R^2	0.978		0.995		0.968	
Machinery, Nec.						
$ln\frac{K^{ICT}}{Y}$	-1.790	-3.705*	_-1.796_	_4.590*_	3.586*	-0.885
	(1.560)	(1.896)	(1.523)	(2.436)	(1.857)	(3.205)
$ln\frac{K}{Y}$	_0.739_	_-9.213*_	0.884	0.833	-1.623	8.380
	(2.905)	(4.136)	(3.626)	(6.613)	(4.671)	(10.38)
N	309		309		309	
R^2	0.984		0.997		0.974	

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Table 16 – *continued from previous page*

Dependent Variable: Relative Compensation Share of the Respective Skill Group						
Industry	High-Skilled		Medium-Skilled		Low-Skilled	
Variable	until 1994	1995-2005	until 1994	1995-2005	until 1994	1995-2005
Electrical and Optical Equipment						
$ln\frac{K^{ICT}}{Y}$	1.176	0.748	-4.185**	2.368	3.010*	-3.115
	(0.720)	(1.529)	(1.370)	(2.323)	(1.529)	(3.213)
$ln\frac{K}{Y}$	-7.283***	-9.441***	2.673	0.230	4.610	9.212
	(2.057)	(2.222)	(4.940)	(4.527)	(6.172)	(6.134)
N	309		309		309	
R^2	0.993		0.997		0.972	
Transport Equipment						
$ln\frac{K^{ICT}}{Y}$	0.734	-5.180**	-3.575**	-0.272	2.840	5.452*
	(0.555)	(1.662)	(1.538)	(2.326)	(1.884)	(2.498)
$ln\frac{K}{Y}$	0.545	-4.971***	-0.271	1.401	-0.273	3.570
	(2.007)	(1.468)	(4.711)	(8.121)	(6.492)	(9.372)
N	309		309		309	
R^2	0.983		0.996		0.969	
Manufacturing Nec.; Recycling						
$ln\frac{K^{ICT}}{Y}$	1.957**	0.319	0.578	-3.266*	-2.534	2.947
	(0.808)	(1.676)	(1.446)	(1.718)	(2.140)	(2.738)
$ln\frac{K}{Y}$	-1.712	-4.793	11.31	12.27*	-9.594	-7.476
	(3.231)	(4.362)	(6.266)	(5.768)	(8.866)	(9.179)
N	306		306		306	
R^2	0.969		0.997		0.975	
Electricity, Gas and Water Supply						
$ln\frac{K^{ICT}}{Y}$	0.455	2.846	-1.606*	0.866	1.151	-3.712*
	(1.114)	(2.168)	(0.805)	(1.339)	(0.865)	(1.995)
$ln\frac{K}{Y}$	-3.095	-9.586	-5.967	-11.05**	9.062	20.63*
	(6.773)	(8.703)	(3.383)	(3.847)	(7.944)	(10.26)
N	309		309		309	
R^2	0.986		0.997		0.974	

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Table 16 – *continued from previous page*

Dependent Variable: Relative Compensation Share of the Respective Skill Group						
Industry	High-Skilled		Medium-Skilled		Low-Skilled	
Variable	until 1994	1995-2005	until 1994	1995-2005	until 1994	1995-2005
Construction						
$ln\frac{K^{ICT}}{Y}$	-0.042	-3.064*	0.756	4.100	-0.713	-1.036
	(0.490)	(1.641)	(1.385)	(3.651)	(1.479)	(3.293)
$ln\frac{K}{Y}$	-1.352	-3.433	5.157	5.612	-3.805	-2.180
	(2.646)	(3.200)	(4.395)	(6.660)	(4.893)	(8.098)
N	307		307		307	
R^2	0.991		0.996		0.983	
Wholesale and Retail Trade						
$ln\frac{K^{ICT}}{Y}$	0.490	-1.551	-3.115**	6.137***	2.624	-4.586
	(0.857)	(1.539)	(1.200)	(1.657)	(1.777)	(2.546)
$ln\frac{K}{Y}$	-4.263	8.820	11.21	9.969	-6.943	-18.79**
	(5.010)	(9.208)	(7.098)	(15.24)	(9.486)	(7.360)
N	309		309		309	
R^2	0.983		0.998		0.974	
Hotels and Restaurants						
$ln\frac{K^{ICT}}{Y}$	0.669	-1.745	-0.727	1.816	0.0576	-0.0705
	(0.750)	(1.517)	(1.502)	(1.483)	(2.099)	(2.407)
$ln\frac{K}{Y}$	6.254	6.125	1.604	8.874	-7.858	-15.00
	(5.441)	(5.614)	(7.411)	(7.196)	(9.682)	(8.619)
N	307		307		307	
R^2	0.960		0.997		0.974	
Transport and Storage						
$ln\frac{K^{ICT}}{Y}$	0.933***	-2.765**	0.007	-0.964	-0.940	3.729*
	(0.188)	(1.052)	(2.332)	(2.553)	(2.416)	(2.009)
$ln\frac{K}{Y}$	-6.712***	-3.820*	1.597	0.0599	5.115	3.760
	(1.581)	(1.769)	(8.766)	(10.76)	(8.704)	(10.74)
N	309		309		309	
R^2	0.977		0.996		0.984	

Continued on next page

Table 16 – *continued from previous page*

Dependent Variable: Relative Compensation Share of the Respective Skill Group						
Industry	High-Skilled		Medium-Skilled		Low-Skilled	
Variable	until 1994	1995-2005	until 1994	1995-2005	until 1994	1995-2005
Post and Telecommunications						
$ln\frac{K^{ICT}}{Y}$	2.347*	1.210	-2.877	5.905*	0.529	-7.115
	(1.070)	(2.249)	(1.868)	(3.188)	(1.647)	(4.788)
$ln\frac{K}{Y}$	-6.108	-8.718**	-3.927	-8.961	10.04	17.68**
	(4.915)	(3.608)	(7.694)	(6.523)	(11.39)	(6.808)
N	309		309		309	
R^2	0.965		0.994		0.972	
Financial Intermediation						
$ln\frac{K^{ICT}}{Y}$	-0.117	3.200	-1.609	0.0585	1.727	-3.259
	(1.411)	(2.841)	(1.063)	(2.652)	(0.996)	(2.241)
$ln\frac{K}{Y}$	4.862	-5.427	-5.942*	-0.298	1.080	5.725*
	(3.981)	(5.074)	(2.857)	(4.538)	(2.919)	(2.788)
N	309		309		309	
R^2	0.990		0.998		0.973	
Real Estate, Renting and Business Activities						
$ln\frac{K^{ICT}}{Y}$	-0.340	1.328	-1.082**	1.311	1.422	-2.639
	(0.805)	(1.952)	(0.446)	(3.628)	(0.926)	(2.471)
$ln\frac{K}{Y}$	1.848	-3.234	9.193**	14.20*	-11.04*	-10.97*
	(3.409)	(4.057)	(3.259)	(7.550)	(5.264)	(5.830)
N	309		309		309	
R^2	0.988		0.995		0.977	

Continued on next page

Table 16 – *continued from previous page*

Dependent Variable: Relative Compensation Share of the Respective Skill Group						
Industry	High-Skilled		Medium-Skilled		Low-Skilled	
Variable	until 1994	1995-2005	until 1994	1995-2005	until 1994	1995-2005
Other Community, Social and Personal Services						
$ln\frac{K^{ICT}}{Y}$	0.134	0.772	0.272	-2.100	-0.406	1.328
	(1.341)	(3.424)	(1.087)	(1.846)	(1.964)	(4.693)
$ln\frac{K}{Y}$	-8.855**	-7.777	*8.055*	*16.31***	0.800	-8.537
	(3.273)	(6.252)	(4.934)	(6.185)	(7.095)	(11.04)
N	309		309		309	
R^2	0.979		0.998		0.956	

***,** ,*: statistically significant at 1, 5, and 10 % level, respectively;
Fixed Effects estimation; Robust standard errors in parentheses;
Year dummies are included in each regression;
The regressions are weighted by average labor costs share of each industry.
Each regressor is interacted with a dummy indicating the period 1970 to 1994
and with one for the period 1995 to 2005.
Coefficients in italic indicate a significant difference between the coefficients
of both time periods on the 10% level.

Appendix B: Bargaining, Openness, and the Labor Share

3 Derivation of Equation (4.9)

$$max_{w,L}\left(L\left(w-\overline{w}\right)\right)^{\alpha}\left(P\left(F\left(K,L\right)\right)F\left(K,L\right)-wL-rK-D\right)^{1-\alpha}$$

First Order Condition with respect to L, where $P=P\left(F\right)$ and $F=F\left(K,L\right)$:

$$\alpha\left(PF-wL-rK-D\right)=\left(1-\alpha\right)\left(w-\frac{\partial P}{\partial F}\frac{\partial F}{\partial L}F-\frac{\partial F}{\partial L}P\right)L$$

Augment this with $\frac{P}{P}$

$$\alpha\left(PF-wL-rK-D\right)=\left(1-\alpha\right)\left(w-\frac{\partial P}{\partial F}\frac{P}{P}\frac{\partial F}{\partial L}F-\frac{\partial F}{\partial L}P\right)L$$

Define the inverse of the product demand elasticity: $\frac{\partial P}{\partial F}\frac{F}{P}=\mu$.

$$\alpha\left(PF-wL-rK-D\right)=\left(1-\alpha\right)\left(w-\mu\frac{\partial F}{\partial L}P-\frac{\partial F}{\partial L}P\right)L$$

$$\alpha\left(PF-wL-rK-D\right)=\left(1-\alpha\right)\left(w-(1+\mu)\frac{\partial F}{\partial L}P\right)L$$

$$wL=\alpha\left(PF-rK-D\right)+P\frac{\partial F}{\partial L}L(1+\mu)$$

Divide this by total revenue: PY, and replace μ by its inverse, the product demand elasticity $|\eta_{Y,P}|$

$$s_L^{IC}=\alpha\left(1-\frac{rK}{PY}-\frac{D}{PY}\right)+\frac{\frac{\partial F}{\partial L}}{F}L(1-\frac{1}{|\eta_{Y,P}|})$$

4 Error-Correction, Unit Roots, and the Labor Share

Error-Correction models are typically applied when time series have unit roots and are co-integrated. Variables which are bounded to be between 0 and 1 should theoretically should not have unit roots in the long-run and should not be cointegrated. Especially, a variable which is bounded should not be integrated with an unbounded variable having a unit root. There cannot be a long run stable relationship if one variable increases or decreases continuously while the other is bounded. Therefore, the model, estimated in this paper, cannot be cointegrated in the very long-run. As I estimate this model for 26 years the long-run relationships show rather a medium-run view of the labor share. In the medium-run it could be possible to observe common movements of bounded variables. In order to account for this, I test for unit roots and cointegration in the model.

First I transform all variables such that the they are no longer bounded. An easy way to do so, is to transform variable x, such that

$$x = ln(x) - ln(a - x), \tag{12}$$

where a is the upper bound of the variable. The largest bounded variable is the capital-output ratio with an upper bound of 26. Therefore, I transform all variables with $a = 26$. Under the transformation the variables are highly correlated with the untransformed variables. Pooling all time series per variable and using panel data unit root test, the tests cannot reject unit root or reject the existence of unit-roots for all variables. I also test the variables by industries for unit roots using the Breitung panel data test for unit roots, which is powerful in for datasets of this size (Breitung, 2000; Breitung and Pesaran, 2005; Breitung and Das, 2005). For the globalization variables, the capital-output ratio and ICT-capital-output ratio the null of unit roots cannot be rejected. For the labor share for two thirds of the industries this hypothesis cannot be rejected. Therefore, I performed panel test for cointegration by Westerlund (Westerlund, 2007; Persyn and Westerlund, 2008). Although time series contain unit roots the H0 of no cointgration cannot be rejected in almost all circumstances. This holds for the full set of regressors as well as individual regressors and sets of regressors. Breitung and Pesaran (2005) discuss the complications with panel data and cointegration as well as unit roots. As a fraction of time series may have unit roots or may be cointegrated is not clear which fraction should be used as threshold to decide a system is cointegrated. Therefore, the estimation results in this paper show the short and long-run dynamics of the variables, but cannot necessarily be regarded as fixed relationships one would assume from co-integrated variables.

5 Descriptive Statistics

Table 17: Description of Relevant Variables.

Variable	Abbreviation	Description	Data Source	availability
Labor Share	LS	total labor compensation over value added	EU KLEMS	industry
Output	Y	real value added	EU KLEMS	industry
Capital-Ouput Ratio	$\frac{K}{Y}$	real gross fixed capital stock over value added	EU KLEMS	industry
ICT-Capital-Output Ratio	$\frac{K^{ICT}}{Y}$	ICT investments over value added	EU KLEMS	industry
Openness	$open$	index of trade flows incl. (imports+exports)/GDP	KOF	country
Economic Restrictions	$rest$	trade and capital account restrictions	KOF	country
Union Coverage	$unioncov$	share of employees in workplaces cov. by ub, adjusted	ICTWSS	country
Unemployment Rate	u	ILO definition	ILO KILM	country
Unemployment Benefits	$unben$	first year gross replacement rate	FRDB	country
Wage Markup	$mark-up$	markup of local wage to average wage of interior market	EU KLEMS	industry
Average Wage Interior Market	$instrument$	average wage of the industry in Europe w/o local market	EU KLEMS	industry
Deflator		deflation of all nominal values with base year 2005	EU KLEMS	industry
Exchange Rate		transferring all values to EURO	IMF	country

Table 18: Set of Countries Analyzed in this Study

Countries	times periods
Austria	1980 - 2005
Denmark	1980 - 2005
Finland	1980 - 2005
Germany	1991 - 2005
Italy	1980 - 2005
Netherlands	1980 - 2005
Portugal	1980 - 2005
Sweden	1993 - 2005
United Kingdom	1980 - 2005
Additional Countries for Robustness Check	
Australia	1982 - 2005
Czech Republic	1995 - 2005
Japan	1980 - 2005
United States	1980 - 2005

Table 19: Set of Industries Analyzed in this Study

Industries
Food, Beverages and Tobacco / Textiles, Textile, Leather and Footwear / Wood and of Wood and Cork / Pulp, Paper, Printing and Publishing / Coke, refined petroleum and nuclear fuel / Chemicals and chemical / Rubber and plastics / Other Non-Metallic Mineral / Basic Metals and Fabricated Metal / Machinery; Nec. / Electrical and Optical Equipment / Transport Equipment / Manufacturing Nec.; Recycling / Electricity, Gas and Water Supply / Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel/ Wholesale trade and commission trade / Retail trade; repair of household goods / Transport and Storage / Post and Telecommunications / Financial Intermediation / Real Estate/ Renting of M+Eq. and Business Activities /
Additional Industries for Robustness Check
Agriculture, Hunting, Forestry, and Fishing / Mining and Quarrying / Construction / Hotels and Restaurants / Research and Development

Table 20: Labor Share by Industry Subgroups

		1980-2005			1985	2005
Variable	Obs	Mean	Min	Max	Mean	Mean
Agriculture	271	73.0	31.2	142.0	71.69	82.89
Mining and Quarrying	297	34.6	2.3	77.6	30.34	30.00
Manufacturing	4095	69.3	4.0	159.5	71.58	66.27
Electricity, Gas and Water Supply	323	32.8	17.2	98.6	35.71	26.52
Construction	297	81.6	53.7	103.8	83.03	78.96
Wholesale and Retail Trade	943	76.0	40.0	114.3	76.13	74.17
Services	2183	60.3	2.4	166.1	62.21	57.60

Source: EU KLEMS, Author’s Calculations.

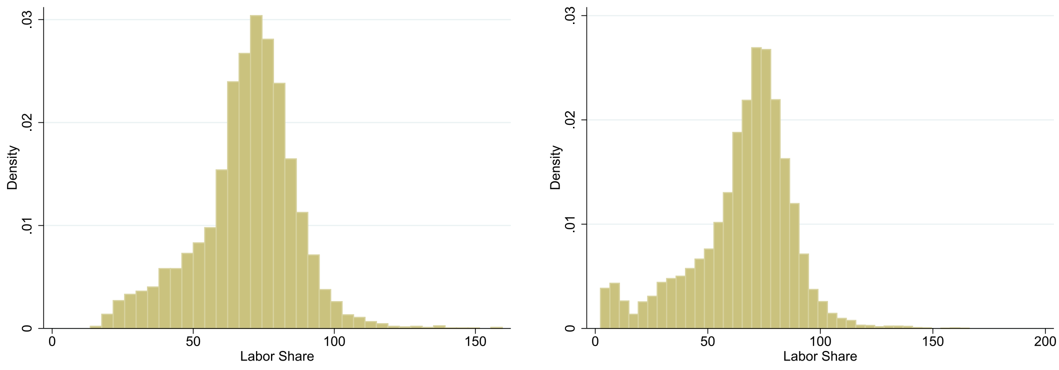

Figure 2: Histograms of the Labor Share; Main Dataset and Dataset for Robustness Estimation; source: EU KLEMS, Author's Calculations.

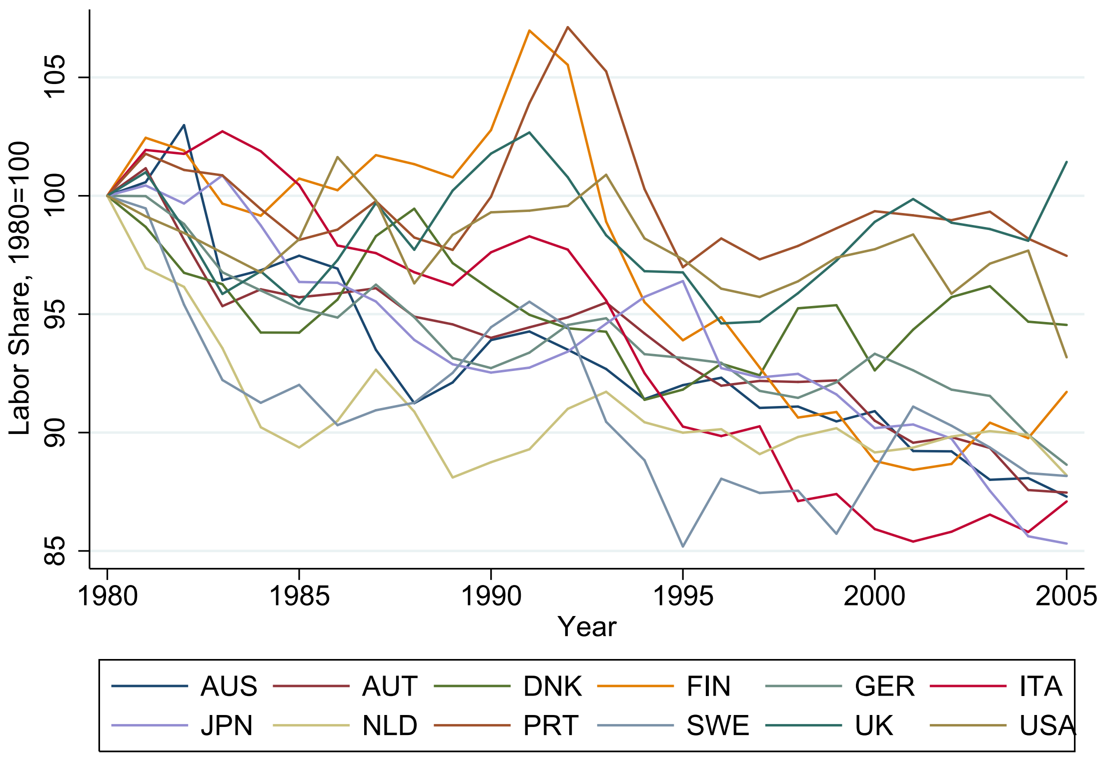

Figure 3: Labor Share Relative to its Value in 1980; Source: EU KLEMS, Author's Calculations.

Table 21: Descriptives on Industry Level

		1980-2005			1985	2005
Variable	Obs	Mean	Min	Max	Mean	Mean
labor share	4836	69.08	13.53	159.54	70.21	65.90
k/y	4045	2.19	0.18	25.93	2.20	2.28
ict/y	4045	0.04	0.00	0.93	0.01	0.08
union coverage	4652	77.09	32.3	99	77.43	76.29
unempl. benefits	4862	47.36	0.5	87.25	48.11	49.36
unemployment rate	4403	7.14	1.6	16.4	7.80	6.95
restrictions	4862	85.86	67.65	97.11	51.37	79.65
openness	4862	61.19	23.45	95.43	79.73	89.30

Source: cf. Table 17, Author's Calculations.

6 Tables: Robustness Analysis

Table 22: Results for Main Regression, by Skill Group, and by Sector (Large Sample)

Dependent Variables: First Difference of the Log Labor Share
of the industry, the Respective Skill Group, or Sector of industry j in country i

	Overall	High	Med. and Low	Low	Manuf.	Services
$ln\ s^i_{L,t-1}$	-0.245***	-0.168***	-0.231***	-0.134***	-0.346***	-0.162***
	(0.038)	(0.038)	(0.036)	(0.047)	(0.055)	(0.024)
$ln\ (K/Y)_{t-1}$	0.047***	0.036**	0.053***	0.037***	0.049	0.052***
	(0.017)	(0.017)	(0.016)	(0.014)	(0.032)	(0.014)
$ln\ \left(K^{ICT}/Y\right)_{t-1}$	0.007	0.009	0.009	0.014	0.004	0.006
	(0.007)	(0.010)	(0.007)	(0.011)	(0.015)	(0.004)
$ln\ union_{t-1}$	0.030*	0.006	0.044***	0.100**	0.026	0.017
	(0.017)	(0.043)	(0.012)	(0.044)	(0.038)	(0.016)
$ln\ unben_{t-1}$	0.002	-0.007**	0.006**	-0.052***	0.012***	-0.007***
	(0.002)	(0.004)	(0.003)	(0.013)	(0.004)	(0.002)
$ln\ u_{t-1}$	0.005	-0.028*	-0.004	-0.010	0.011	-0.016***
	(0.009)	(0.015)	(0.006)	(0.012)	(0.018)	(0.006)
$ln\ rest_{t-1}$	-0.054	0.126	-0.018	0.017	-0.126	0.010
	(0.056)	(0.134)	(0.048)	(0.150)	(0.115)	(0.046)
$ln\ open_{t-1}$	-0.067***	-0.070**	-0.068***	0.007	-0.104***	-0.020
	(0.014)	(0.034)	(0.019)	(0.045)	(0.021)	(0.018)

Continued on next page

Table 22 – *continued from previous page*

	Overall	High	Med. and Low	Low	Manuf.	Services
$\Delta\ ln\ (K/Y)_t$	0.202**	0.210**	0.205**	0.214**	0.172*	0.375***
	(0.092)	(0.092)	(0.091)	(0.091)	(0.095)	(0.053)
$\Delta\ ln\ (K/Y)_{t-1}$	0.047	0.045	0.040	0.028	0.080	-0.052*
	(0.059)	(0.059)	(0.059)	(0.064)	(0.065)	(0.027)
$\Delta\ ln\ (K/Y)_{t-2}$	-0.019	-0.024	-0.026	-0.044	-0.010	-0.055
	(0.039)	(0.047)	(0.038)	(0.040)	(0.047)	(0.036)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_t$	-0.015***	-0.020***	-0.011**	-0.003	-0.028***	-0.004
	(0.005)	(0.008)	(0.005)	(0.008)	(0.008)	(0.005)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_{t-1}$	-0.015	-0.018	-0.015	-0.009	-0.027*	0.001
	(0.009)	(0.011)	(0.010)	(0.008)	(0.015)	(0.007)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_{t-2}$	-0.002	-0.002	-0.001	0.013*	-0.006	0.000
	(0.005)	(0.006)	(0.005)	(0.007)	(0.011)	(0.008)
$\Delta\ ln\ union_t$	0.105***	-0.156**	0.140***	0.182*	0.279***	-0.104*
	(0.040)	(0.072)	(0.040)	(0.102)	(0.075)	(0.061)
$\Delta\ ln\ union_{t-1}$	0.050	0.155	0.014	-0.035	0.040	0.137***
	(0.081)	(0.126)	(0.068)	(0.134)	(0.159)	(0.048)
$\Delta\ ln\ union_{t-2}$	0.013	-0.219***	0.011	0.177	0.060	-0.045
	(0.043)	(0.065)	(0.051)	(0.160)	(0.070)	(0.036)
$\Delta\ ln\ unben_t$	0.004	0.013*	0.007***	-0.018*	0.012**	-0.012***
	(0.003)	(0.007)	(0.003)	(0.010)	(0.006)	(0.004)
$\Delta\ ln\ unben_{t-1}$	0.008**	0.015**	0.007*	0.028***	0.004	0.016***
	(0.003)	(0.007)	(0.004)	(0.007)	(0.005)	(0.003)
$\Delta\ ln\ unben_{t-2}$	-0.003	0.010	-0.002	0.017	-0.013	0.002
	(0.008)	(0.009)	(0.007)	(0.011)	(0.016)	(0.003)
$\Delta\ ln\ u_t$	-0.003	0.008	-0.013	-0.032	0.003	-0.034***
	(0.018)	(0.033)	(0.016)	(0.042)	(0.030)	(0.011)
$\Delta\ ln\ u_{t-1}$	-0.045***	0.001	-0.042**	-0.028	-0.062**	-0.015
	(0.017)	(0.042)	(0.017)	(0.019)	(0.026)	(0.012)
$\Delta\ ln\ u_{t-2}$	-0.007	0.009	-0.002	-0.005	-0.012	0.006
	(0.013)	(0.036)	(0.012)	(0.021)	(0.024)	(0.008)
$\Delta\ ln\ rest_t$	-0.162**	-0.085	-0.162**	-0.277**	-0.273*	0.065
	(0.070)	(0.159)	(0.067)	(0.140)	(0.144)	(0.054)
$\Delta\ ln\ rest_{t-1}$	-0.018	-0.188	-0.038	-0.034	0.005	-0.064
	(0.053)	(0.125)	(0.062)	(0.134)	(0.107)	(0.066)
$\Delta\ ln\ rest_{t-2}$	-0.041	-0.037	-0.036	0.225	0.011	0.016
	(0.087)	(0.161)	(0.074)	(0.205)	(0.076)	(0.080)

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Table 22 – *continued from previous page*

	Overall	High	Med. and Low	Low	Manuf.	Services
Δ *ln open*$_t$	-0.066***	-0.062	-0.068***	-0.052	-0.088**	-0.024
	(0.020)	(0.040)	(0.022)	(0.040)	(0.035)	(0.019)
Δ *ln open*$_{t-1}$	-0.023	-0.033	-0.017	-0.039	-0.016	-0.028
	(0.021)	(0.041)	(0.022)	(0.053)	(0.024)	(0.021)
Δ *ln open*$_{t-2}$	0.027**	0.042	0.031**	0.041	0.027	0.014
	(0.011)	(0.036)	(0.012)	(0.035)	(0.020)	(0.013)
cons	0.183	0.772	2.124***	0.856	0.668	0.044
	(0.215)	(0.554)	(0.435)	(0.688)	(0.444)	(0.180)
$time - trend$	✓	✓	✓	✓	✓	✓
$time - trend^2$	✓	✓	✓	✓	✓	✓
N	5865	5865	5865	5865	2968	2032
r2	0.208	0.155	0.202	0.192	0.242	0.261

Cluster robust standard errors in parentheses with two-way clustering on country and industry-country level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 23: Pre and Post 94

Dependent Variable: First Difference of the Log Labor Share Estimation with Small Sample for Europe						
	Small Sample		Manufacturing		Services	
	1980-1993	1994-2005	1980-1993	1994-2005	1980-1993	1994-2005
$ln\ s_{L,t-1}$	-0.319***	-0.290***	-0.347***	-0.317***	-0.249***	-0.241***
	(0.040)	(0.052)	(0.048)	(0.064)	(0.017)	(0.020)
$ln\ (K/Y)_{t-1}$	0.059**	0.048	0.064**	0.040	0.068***	0.072***
	(0.029)	(0.030)	(0.030)	(0.042)	(0.019)	(0.020)
$ln\ \left(K^{ICT}/Y\right)_{t-1}$	*0.005*	*-0.007*	*-0.001*	*-0.016*	0.016***	0.009*
	(0.007)	*(0.009)*	*(0.008)*	*(0.014)*	(0.002)	(0.005)
$ln\ union_{t-1}$	*0.106***	*0.043**	*0.167****	*0.035*	*0.009*	*0.054**
	(0.050)	*(0.025)*	*(0.062)*	*(0.029)*	*(0.041)*	*(0.029)*
$ln\ unben_{t-1}$	0.003	-0.009**	0.005	0.002	-0.004	-0.018**
	(0.006)	(0.005)	(0.008)	(0.006)	(0.005)	(0.007)
$ln\ u_{t-1}$	0.007	0.006	0.004	0.006	0.005	0.005
	(0.017)	(0.016)	(0.024)	(0.026)	(0.013)	(0.010)
$ln\ rest_{t-1}$	-0.018	0.021	0.007	0.115	-0.081	-0.127
	(0.109)	(0.060)	(0.163)	(0.091)	(0.119)	(0.106)
$ln\ open_{t-1}$	-0.091	-0.068***	-0.073	-0.065**	-0.091***	-0.084*
	(0.056)	(0.024)	(0.080)	(0.028)	(0.034)	(0.047)
$\Delta\ ln\ (K/Y)_t$	*0.370****	*0.324****	*0.402****	*0.308****	0.402***	0.412***
	(0.105)	*(0.107)*	*(0.105)*	*(0.119)*	(0.037)	(0.042)
$\Delta\ ln\ (K/Y)_{t-1}$	*0.117**	*0.142***	*0.139***	*0.171****	-0.011	-0.004
	(0.060)	*(0.065)*	*(0.062)*	*(0.062)*	(0.031)	(0.030)
$\Delta\ ln\ (K/Y)_{t-2}$	*-0.030*	*-0.005*	*-0.039*	*0.002*	-0.009	-0.004
	(0.053)	*(0.058)*	*(0.058)*	*(0.073)*	(0.039)	(0.034)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_t$	*-0.005*	*-0.016***	*-0.007*	*-0.020***	*-0.005*	*-0.012***
	(0.011)	*(0.008)*	*(0.015)*	*(0.009)*	*(0.007)*	*(0.006)*
$\Delta\ ln\ \left(K^{ICT}/Y\right)_{t-1}$	-0.014**	-0.000	*-0.026****	*0.001*	0.005	0.006
	(0.006)	(0.009)	*(0.007)*	*(0.014)*	(0.011)	(0.010)
$\Delta\ ln\ \left(K^{ICT}/Y\right)_{t-2}$	*0.004*	*0.014**	*0.005*	*0.022***	-0.012	-0.013
	(0.006)	*(0.008)*	*(0.009)*	*(0.011)*	(0.012)	(0.010)
$\Delta\ ln\ union_t$	0.019	0.042	-0.013	0.023	0.004	0.014
	(0.070)	(0.058)	(0.115)	(0.097)	(0.097)	(0.084)
$\Delta\ ln\ union_{t-1}$	*0.025*	*0.062*	*-0.122*	*-0.029*	0.285***	0.242***
	(0.133)	*(0.118)*	*(0.189)*	*(0.168)*	(0.084)	(0.057)
$\Delta\ ln\ union_{t-2}$	*-0.086*	*-0.028*	*-0.107*	*-0.017*	-0.013	-0.017
	(0.054)	*(0.051)*	*(0.069)*	*(0.065)*	(0.056)	(0.057)

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Table 23 – *continued from previous page*

	Small Sample		Manufacturing		Services	
	1980-1993	1994-2005	1980-1993	1994-2005	1980-1993	1994-2005
Δ *ln unben*$_t$	*0.003*	*-0.012*	0.014***	0.000	-0.014**	-0.027*
	(0.005)	*(0.010)*	(0.005)	(0.009)	(0.006)	(0.014)
Δ *ln unben*$_{t-1}$	0.005	0.029***	0.002	0.025**	*0.014****	*0.026****
	(0.005)	(0.007)	(0.006)	(0.011)	*(0.004)*	*(0.006)*
Δ *ln unben*$_{t-2}$	-0.005	0.005	-0.005	0.002	-0.004	0.004
	(0.009)	(0.009)	(0.011)	(0.013)	(0.006)	(0.006)
Δ *ln u*$_t$	-0.008	-0.014	0.002	-0.009	-0.026*	-0.029
	(0.021)	(0.020)	(0.033)	(0.026)	(0.015)	(0.020)
Δ *ln u*$_{t-1}$	-0.030*	-0.020	-0.026	-0.014	-0.024**	-0.026***
	(0.017)	(0.018)	(0.023)	(0.024)	(0.011)	(0.010)
Δ *ln u*$_{t-2}$	-0.012	0.003	-0.008	0.008	-0.019	-0.015
	(0.023)	(0.015)	(0.032)	(0.023)	(0.015)	(0.016)
Δ *ln rest*$_t$	-0.081	-0.137*	-0.120	-0.169	0.006	-0.026
	(0.085)	(0.077)	(0.127)	(0.116)	(0.079)	(0.067)
Δ *ln rest*$_{t-1}$	-0.096*	-0.149***	-0.158**	-0.239***	0.023	0.029
	(0.056)	(0.042)	(0.076)	(0.047)	(0.078)	(0.088)
Δ *ln rest*$_{t-2}$	*-0.071*	*-0.129*	*-0.162*	*-0.239**	0.133	0.116
	(0.103)	*(0.111)*	*(0.142)*	*(0.145)*	(0.087)	(0.096)
Δ *ln open*$_t$	-0.083**	-0.039	-0.078*	-0.048	-0.068	-0.041
	(0.037)	(0.025)	(0.045)	(0.036)	(0.052)	(0.036)
Δ *ln open*$_{t-1}$	0.054	0.059*	0.058	0.050	*0.040*	*0.070****
	(0.052)	(0.032)	(0.077)	(0.049)	*(0.026)*	*(0.020)*
Δ *ln open*$_{t-2}$	0.037*	0.031	0.032	0.021	0.031	0.044
	(0.021)	(0.033)	(0.035)	(0.047)	(0.023)	(0.035)
cons		-0.231		-0.743		0.719
		(0.356)		(0.525)		(0.446)
$time - trend$		✓		✓		✓
$time - trend^2$		✓		✓		✓
N		3259		2160		1099
r2		0.315		0.332		0.344

Results in italics indicate a significant difference between the two periods on the 10 percent level. Cluster robust standard errors in parentheses with two-way clustering on country and industry-country level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix C: Monitoring and the Labor Share

7 Figures: Simulation Results

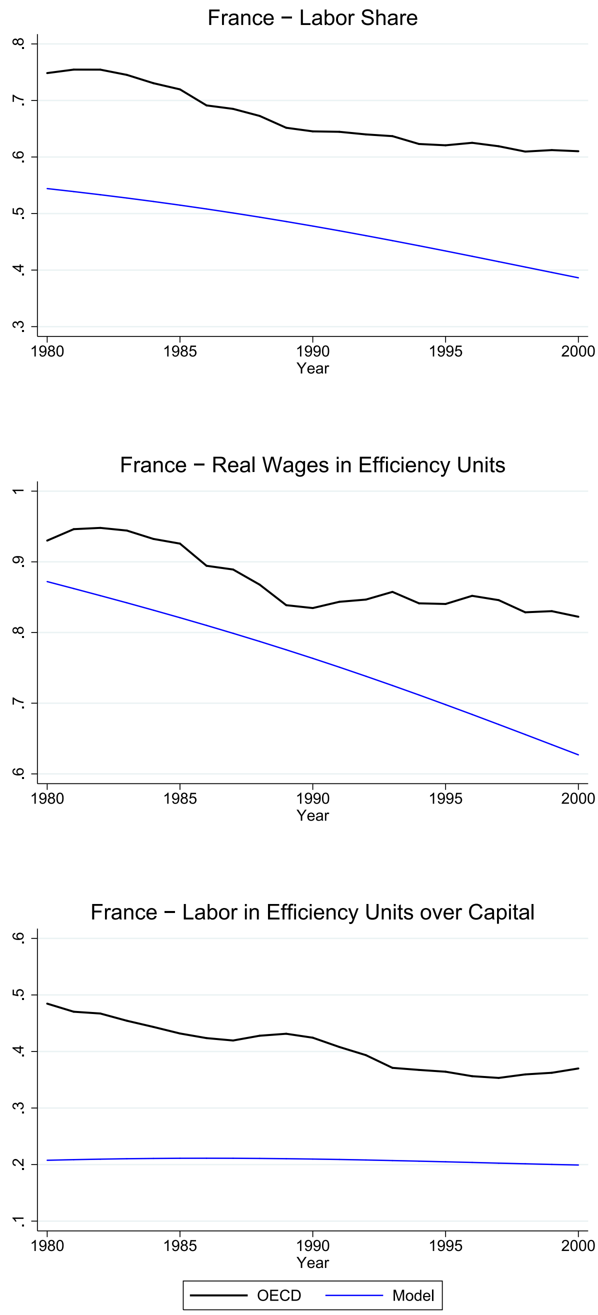

Figure 4: France: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data and the dotted the simulated approximation.

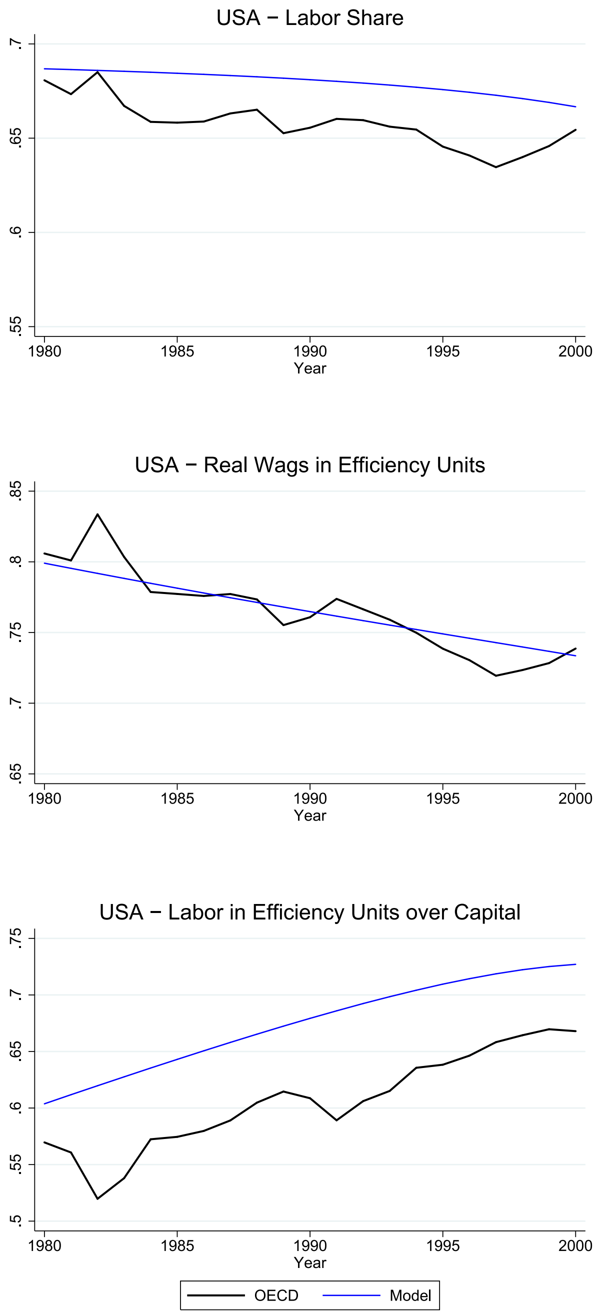

Figure 5: USA: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data and the dotted the simulated approximation.

Figure 6: Australia: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

Figure 7: Belgium: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

Figure 8: Italy: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

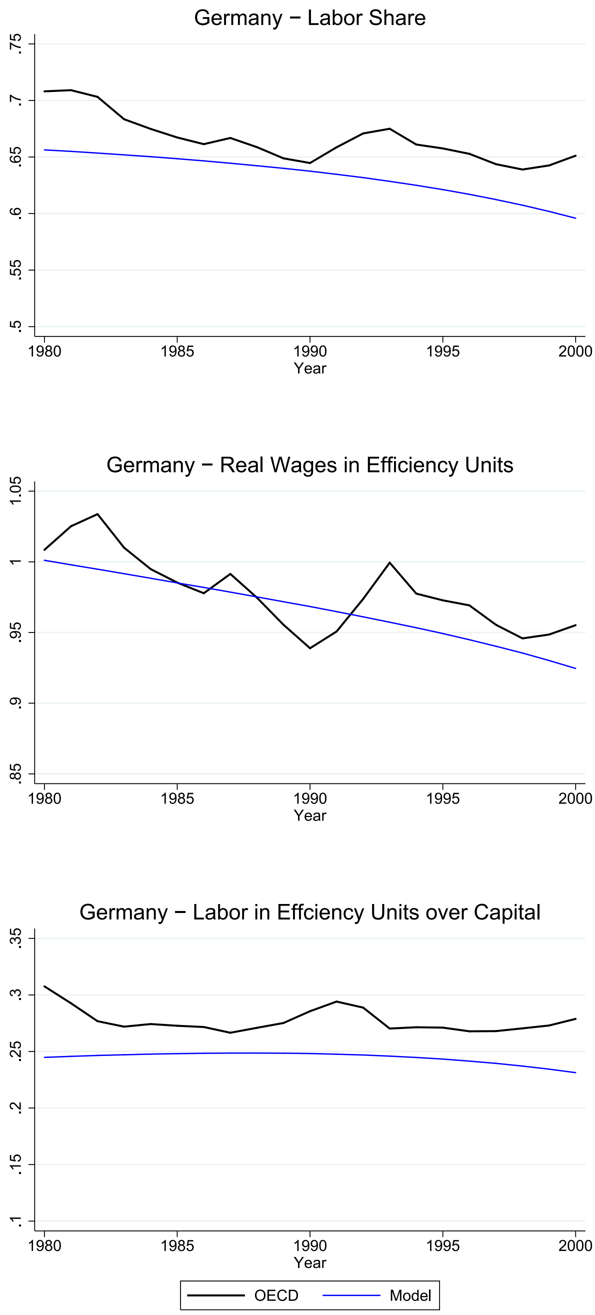

Figure 9: Germany: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

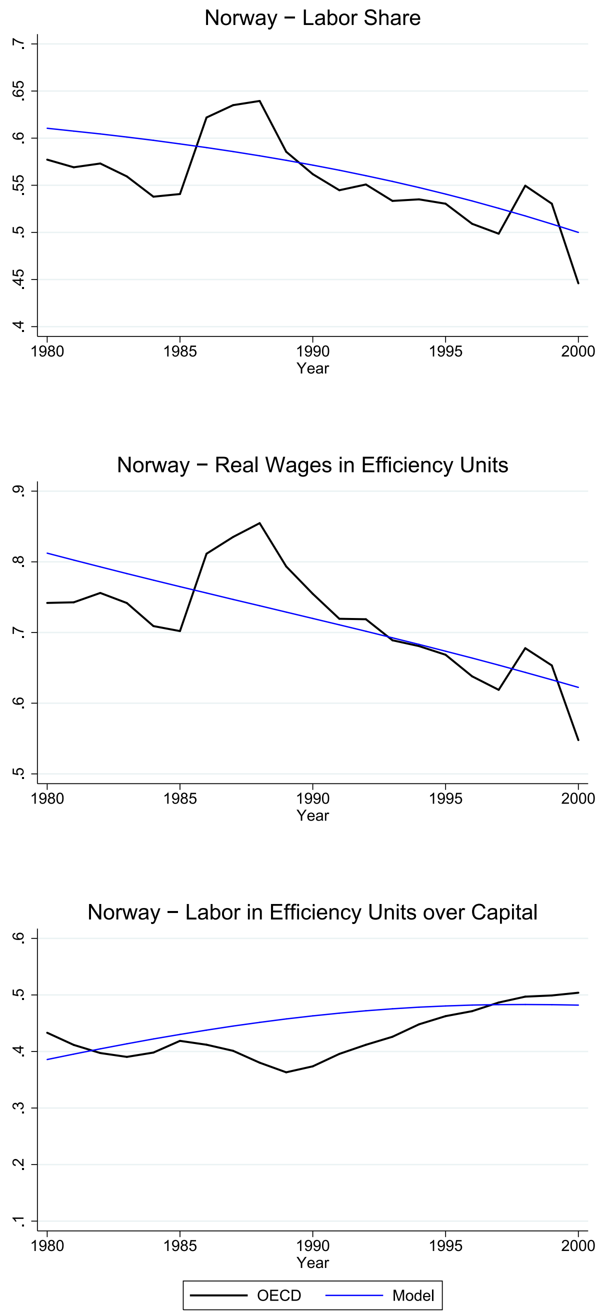

Figure 10: Norway: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

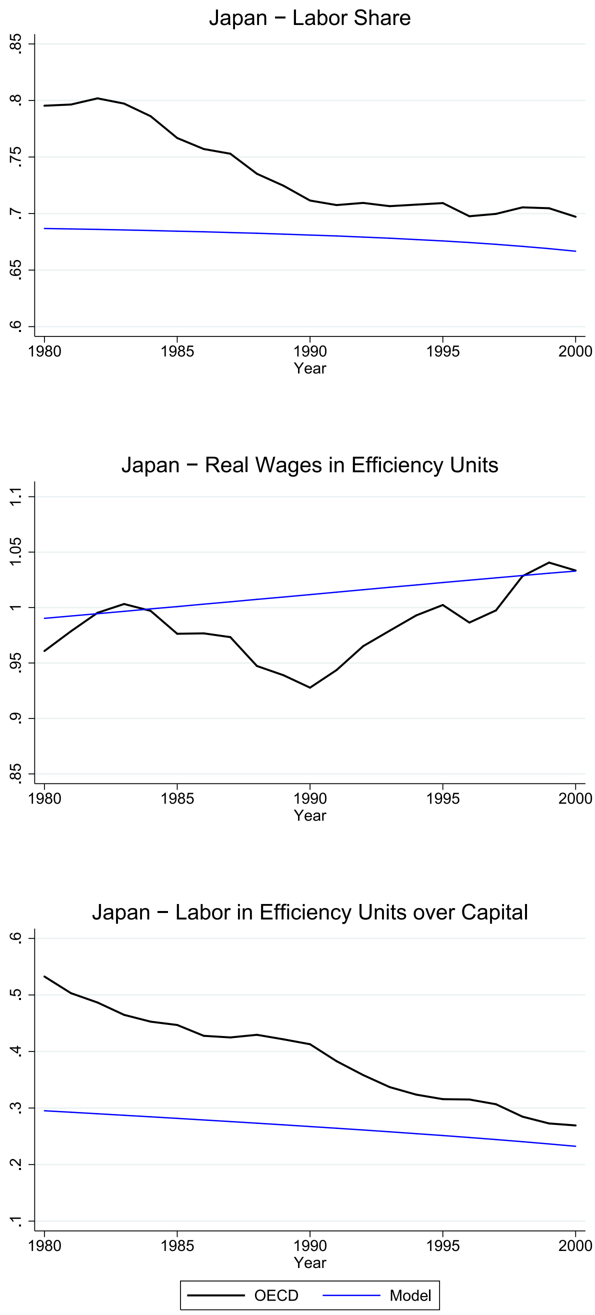

Figure 11: Japan: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

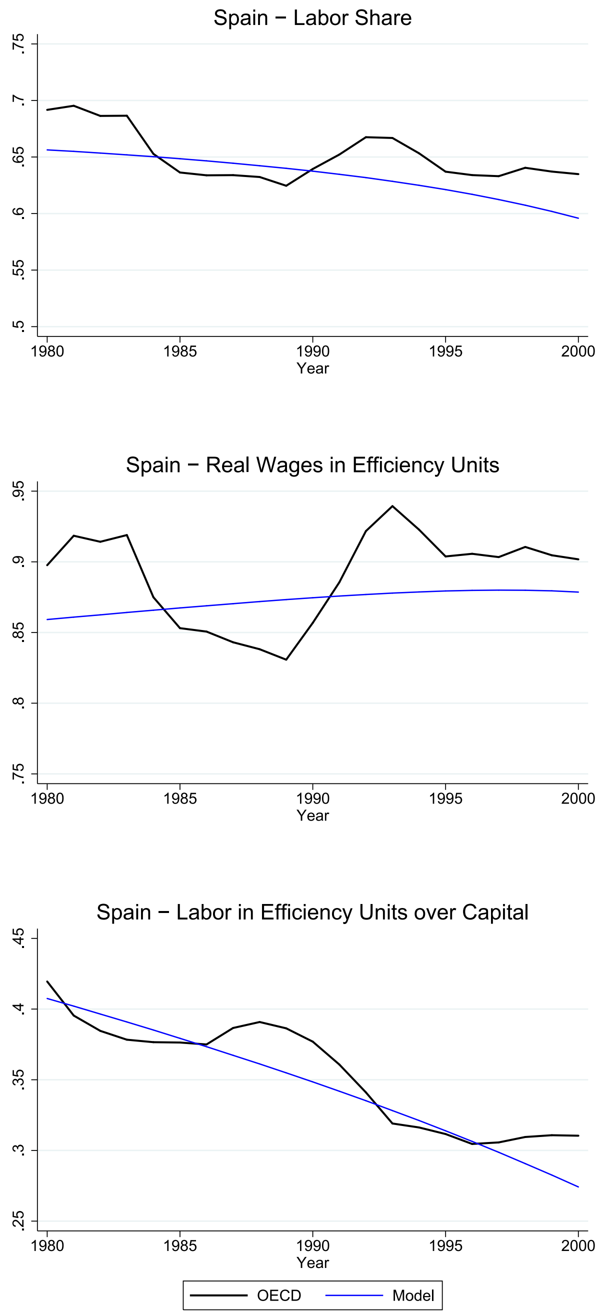

Figure 12: Spain: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data, the blue line depicts the simulated data.

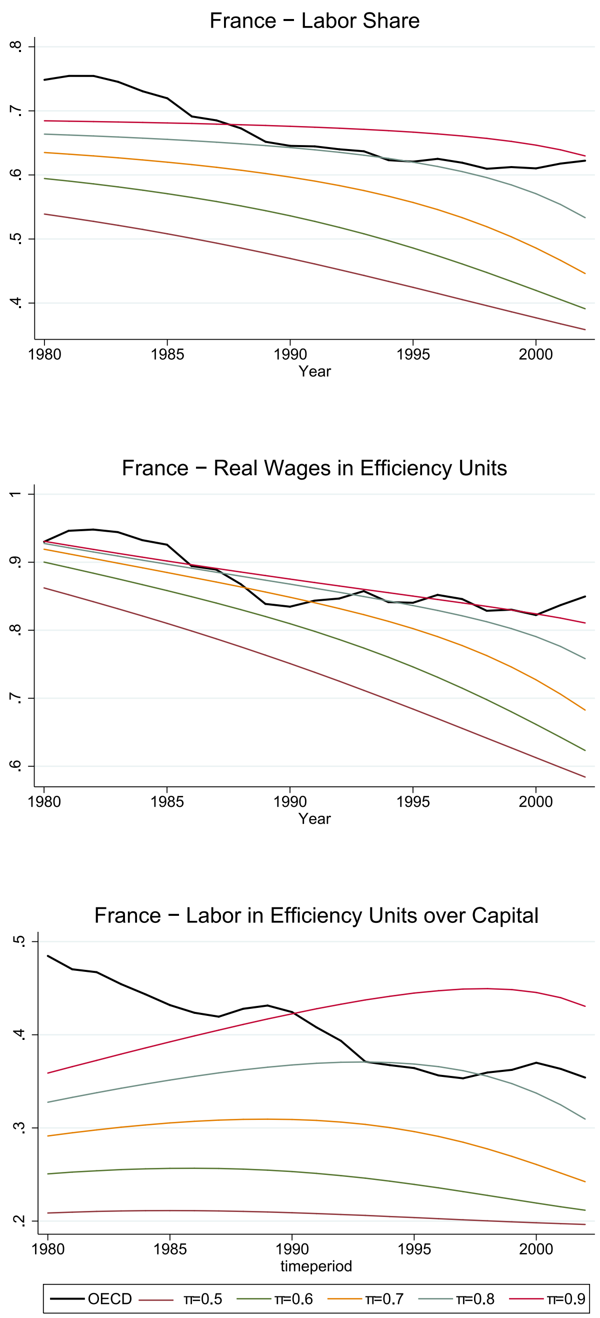

Figure 13: France: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data. The other lines show a biased social planner. The lowest dashed line shows the results for $\pi = 0.5$. Each line up shows the simulation results for $\pi = 0.6$ up to $\pi = 0.9$. The higher the worker's weight is, the higher is the simulated graph.

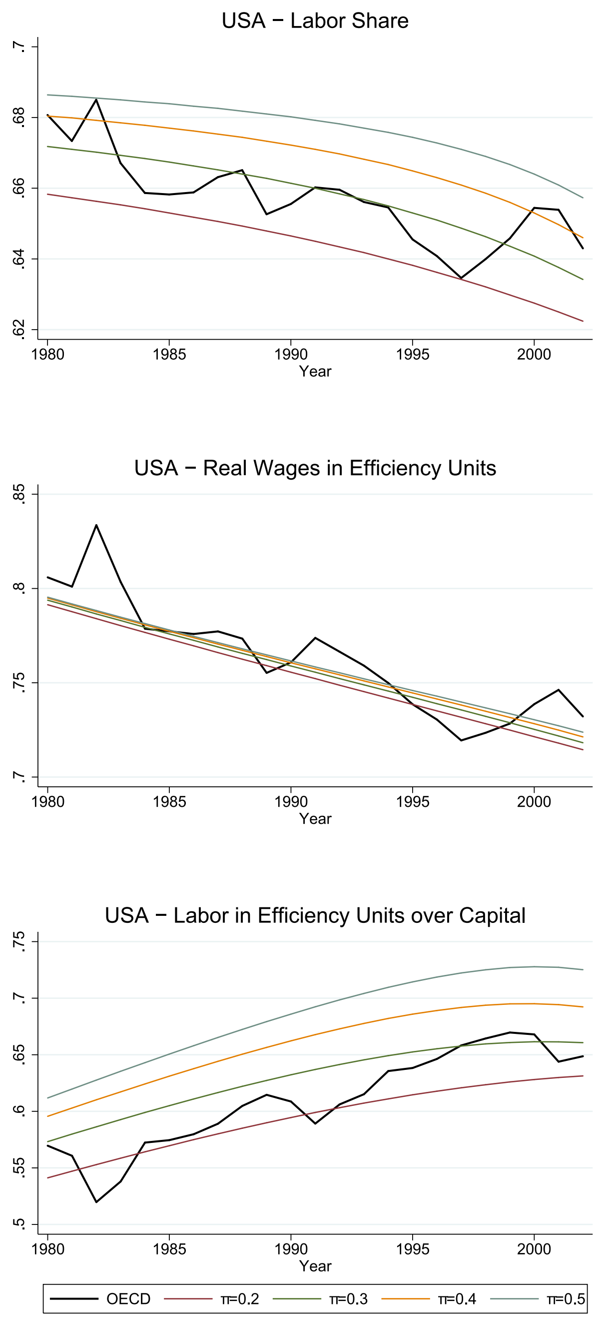

Figure 14: USA: Labor Shares, Real Wages in Efficiency Units and Labor in Efficiency Units over Capital. The black line depicts the real data. The other lines show a biased social planner. The highest dashed line shows the results for $\pi = 0.5$. Each line down shows the simulation results for $\pi = 0.4$ up to $\pi = 0.2$. The lower the worker's weight is, the lower is the simulated graph.

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Selbständigkeitserklärung

Ich bezeuge durch meine Unterschrift, dass meine Angaben über die bei der Abfassung meiner Dissertation benutzten Hilfsmittel, über die mir zuteil gewordene Hilfe sowie über frühere Begutachtungen meiner Dissertation in jeder Hinsicht der Wahrheit entsprechen.

Berlin, den 14.10.2011 Dorothee Schneider